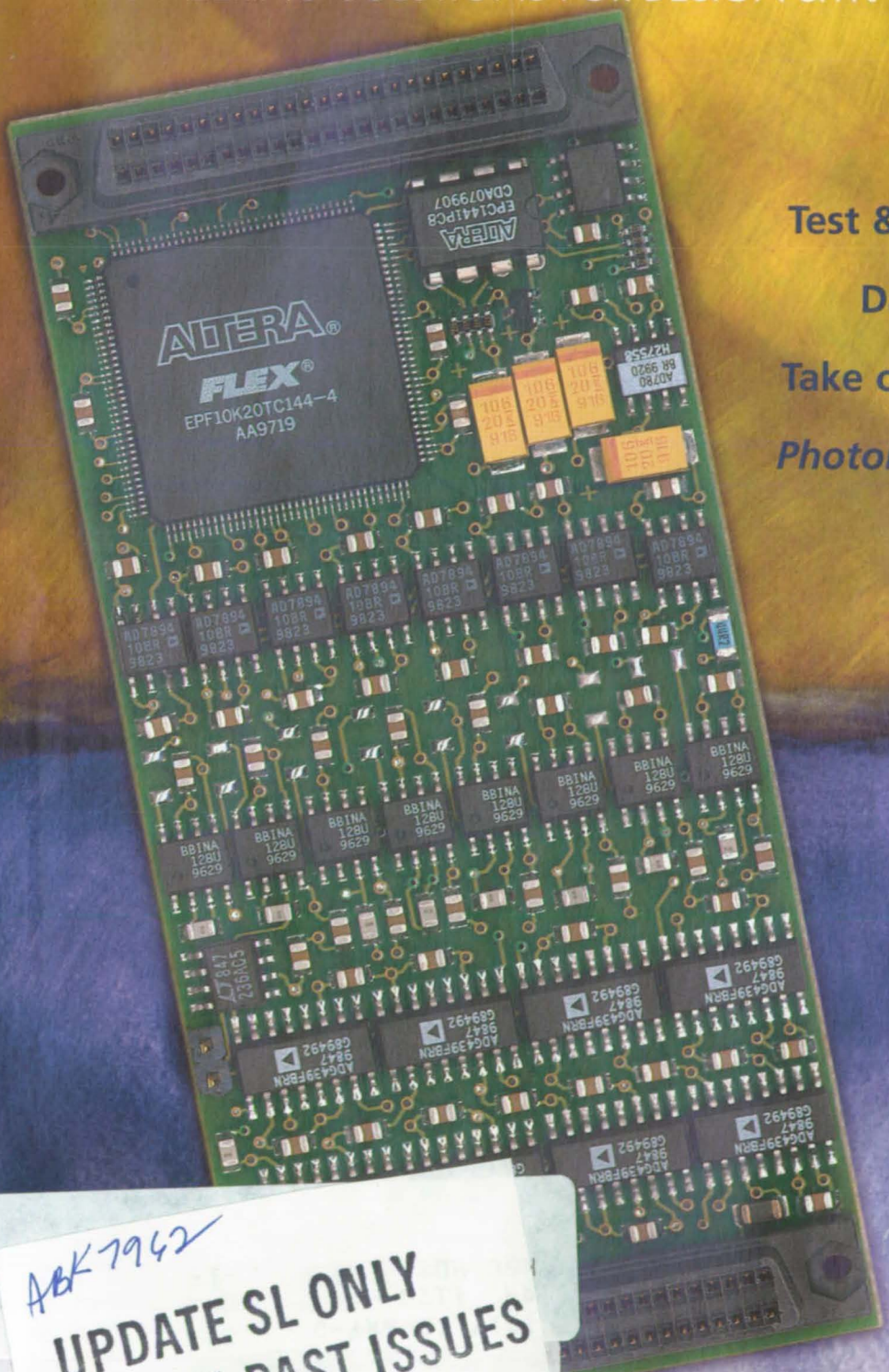
July 2000

Vol. 24 No. 7

TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING



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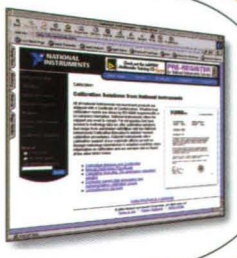

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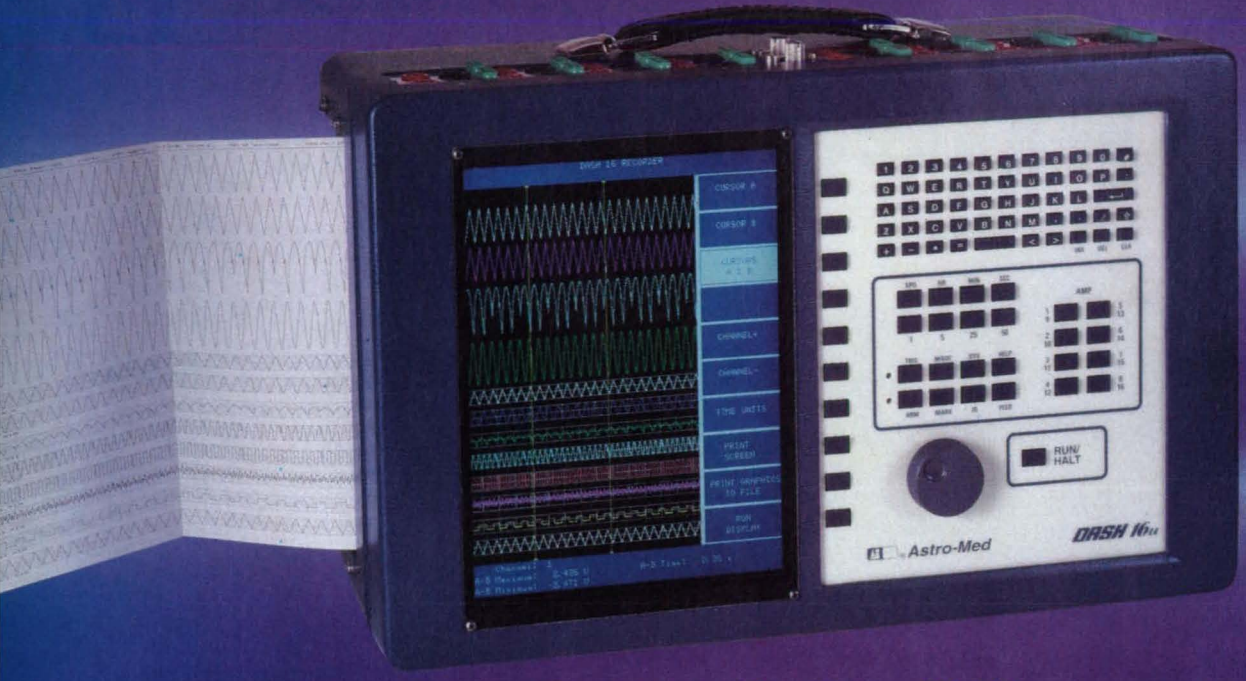

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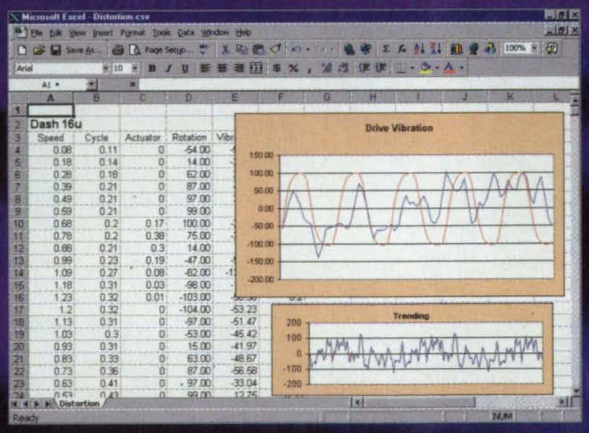

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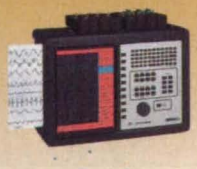

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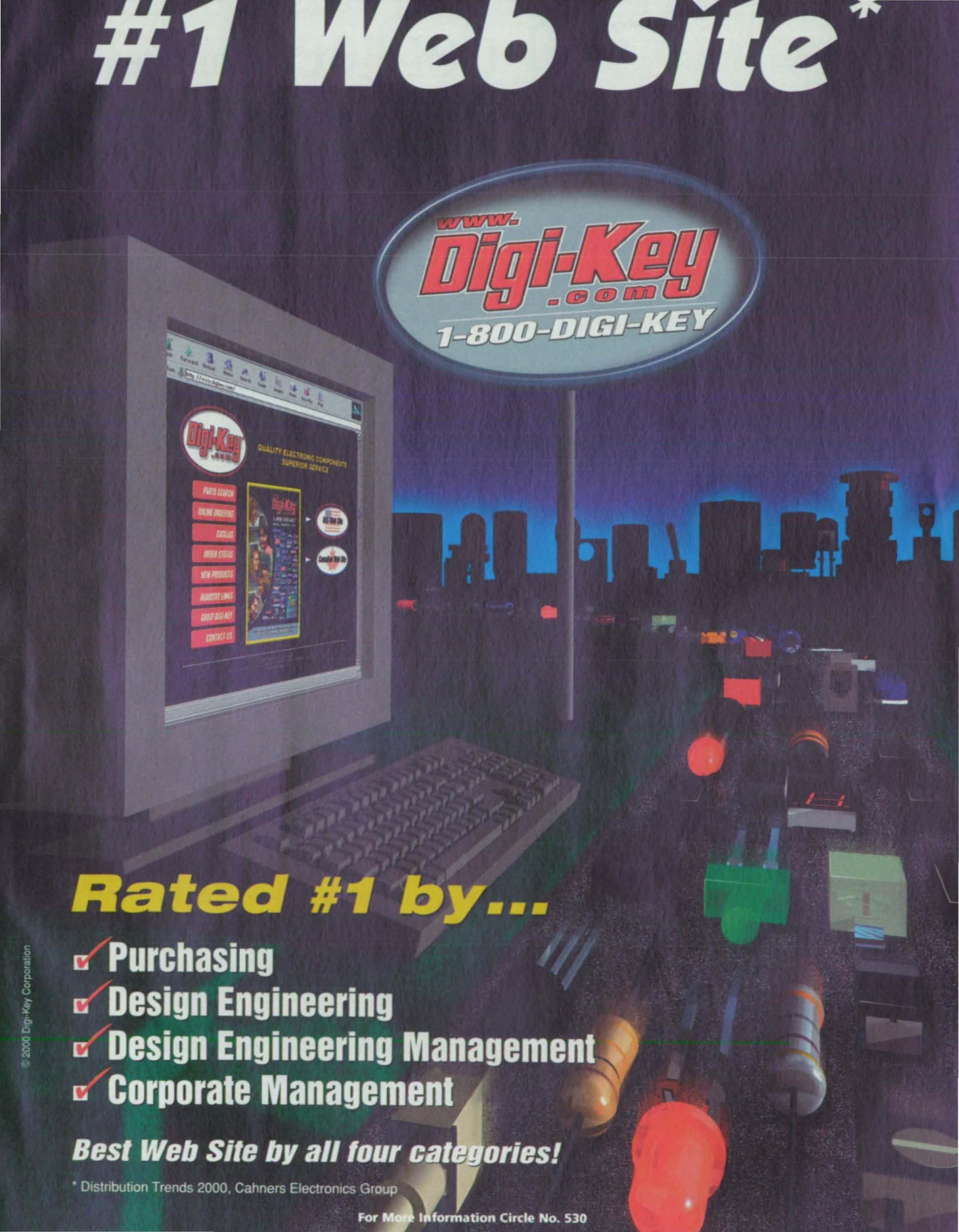

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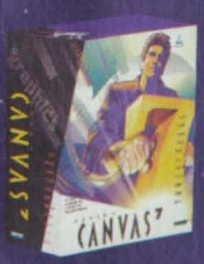

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FEATURES

BRIEFS

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PRODUCT OF THE MONTH

The webDAQ/100 from Capital Equipment Corp., Billerica, MA, combines A/D and D/A hardware with a built-in web server for data acquisition and download.

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ON THE COVER

The IP340 IndustryPack® is an analog input module from Acromag, Wixom, MI (www.acromag.com), that features two eight-channel banks and eight A/D converters with simultaneous sampling capability. ActiveX controls link I/O data to desktop applications used to display and record data. The IndustryPack is one of six new products described on page 36 as part of this month's Special Coverage on Data Acquisition, which begins on page 28.

(Photo courtesy of Acromag)

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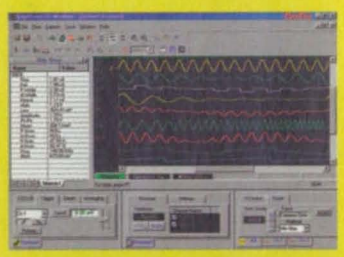

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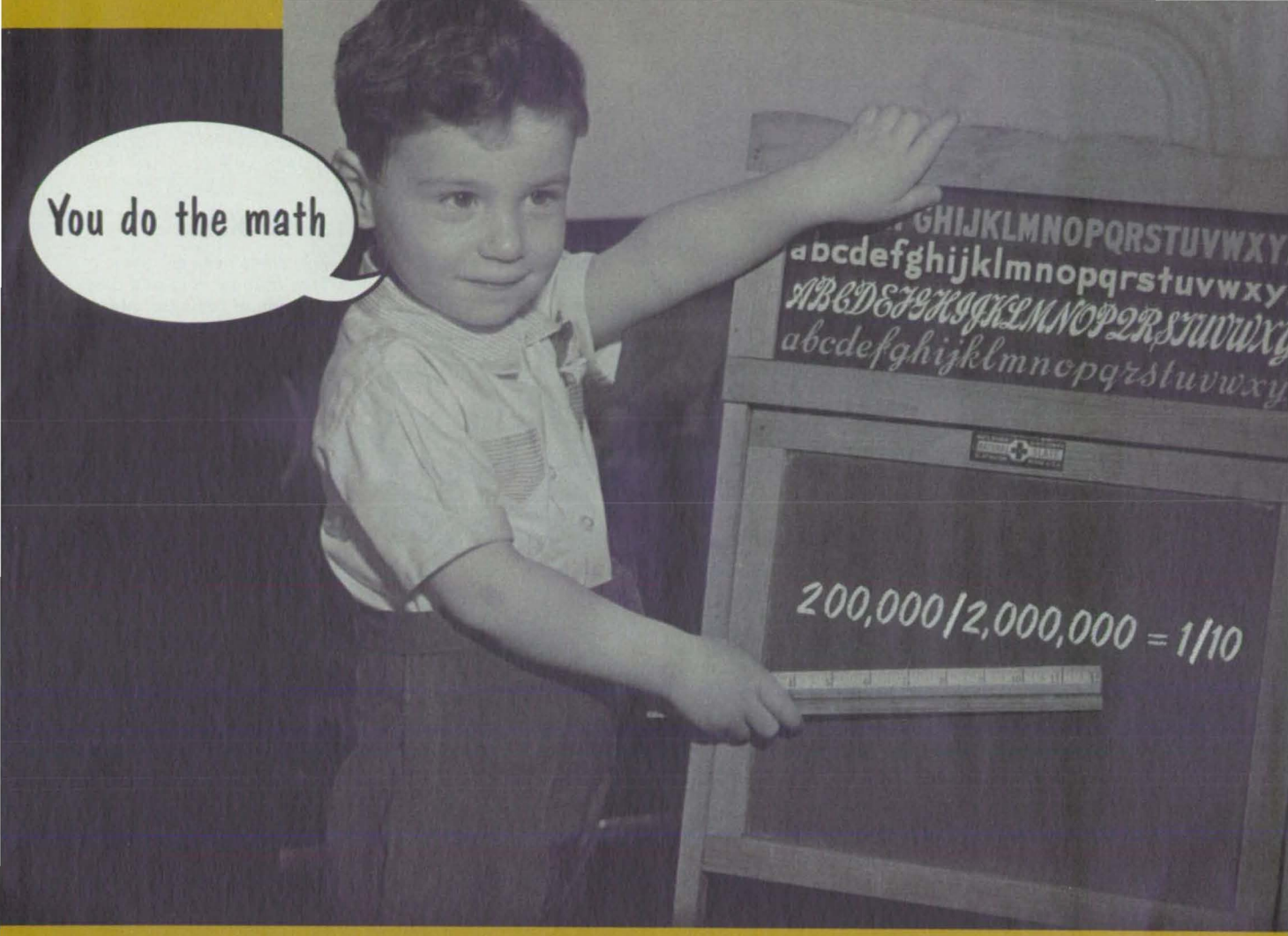

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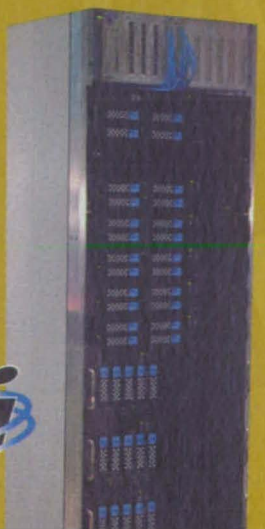

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NASA Commercial Technology Team

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NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-1754
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Remote Sensing; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(281) 483-0474
henry.l.davis1@jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Fluids and Fluid Systems; Materials Evaluation; Process Engineering; Command, Control and Monitor Systems; Range Systems; Environmental Engineering and Management.
Jim Aliberti
(321) 867-6224
Jim.Aliberti-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Sam Morello
(757) 864-6005
s.a.morello@larc.nasa.gov

John H. Glenn Research Center at Lewis Field
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@grc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Sally Little
(256) 544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
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NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
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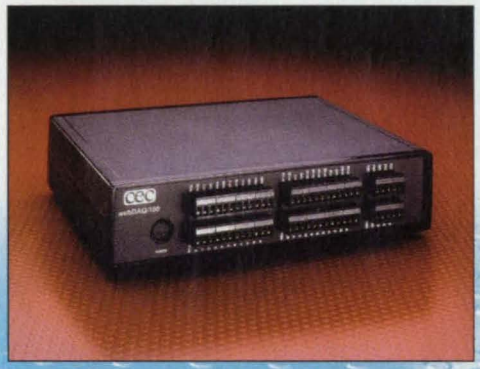

Capital Equipment Corp., Billerica, MA, has introduced webDAQ/100, a web-based data acquisition device that combines A/D and D/A hardware with web technology. With a built-in web server, the system contains its own user interface. The user plugs the system into a network connection, starts up their web browser, and configures acquisition parameters, start and stop operations, and data reports. When data is required, it can be downloaded directly into Excel. The system can be used with any computer that has an Ethernet port, connected locally, or multiple systems can be used at remote sites for unattended data logging. The unit features up to 32 MB of internal RAM, 500 KHz throughput at 12-bit accuracy on 32 input channels, eight D/A output channels, and the ability to sample at multiple data rates simultaneously.

For More Information Circle No. 753

NASA Partners With Veterans Agency

NASA and the Department of Veterans Affairs (VA) signed an agreement on May 30 to initiate a NASA-operated voluntary patient safety protection system. By forging the alliance with NASA, the VA will tap into NASA's expertise on safety issues to implement and operate a system for recording and analyzing medical errors and "close calls." The VA operates 172 medical centers that last year treated more than 3.3 million patients.

NASA will operate the VA Patient Safety Reporting System that is modeled after the NASA-administered Aviation Safety Reporting System (ASRS), which is funded by the Federal Aviation Administration (FAA). The ASRS collects, analyzes, and responds to voluntarily submitted aviation safety incident reports in order to lessen the likelihood of aviation accidents.

For more information, contact NASA Ames' Public Affairs Office at 650-604-2162; the VA Office of Public Affairs at 202-273-6000, or visit www.arc.nasa.gov.

The Need for Speed

Computers used to work in milliseconds (1,000ths), then went to microseconds (millionths), and now are approaching nanoseconds (billionths) for logic operations, and picoseconds (trillionths) for the switches and gates in chips. "That's great in theory," said Dr. Donald Frazier of NASA's Marshall Space Flight Center in Huntsville, AL. But, electronic signals, even with Very Large Scale Integration (VLSI) and maximum miniaturization, "are bogged down by many aspects of the solid materials they travel through. So we've had to find a faster medium for the signals — and the answer seems to be light itself."

Light travels at 186,000 miles per second. In a billionth of a second, or one nanosecond, photons of light travel just a bit less than a foot. That would be perfect for doing things very quickly in microminiaturized computer chips. Newer advances, said Frazier, have produced a variety of thin films and optical fibers that make optical interconnections and devices practical. "We are focusing on thin films made of organic molecules, which are more light sensitive than inorganics. What we are accomplishing in the lab today will result in the development of super-fast, super-miniaturized, super-lightweight, and lower cost optical computing and optical communication devices and systems," Frazier explained.

The rapid growth of the Internet demands faster speeds and larger bandwidths than electronic circuits can provide. Frazier and Dr. Hossin Abdeldayem of NASA Marshall have designed and built all-optical logic gate circuits for data processing at gigabit and terabit rates, and they are working on a system for pattern recognition.

For more information, visit Marshall's NASA Science News web site at http://science.nasa.gov.

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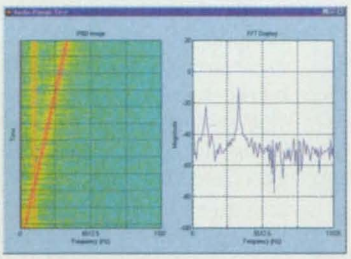

The new MATLAB Data Acquisition Toolbox lets you read data directly from acquisition hardware into MATLAB for analysis.

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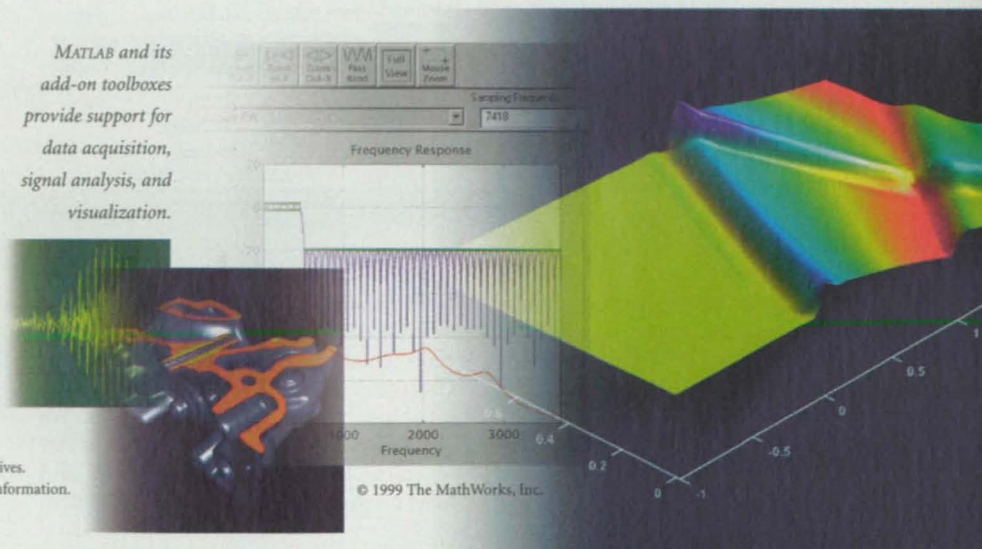

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features

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Online Tour

The *NASA Tech Briefs* web sites are designed to complement the magazine and its market-focus supplements by offering a wide range of interactive features, including the ability to download free NASA technical reports, and access daily industry news. To help you derive optimum benefit from our sites, we invite you to log on to **www.nasatech.com** and take this guided tour.

On the left-hand side of the *NASA Tech Briefs* home page are links to the week's news headlines, the current "Who's Who at NASA" interview, and NTB's Product of the Month. To go directly to one of these features, click on the headline. Clicking on the word **News** at the top of the column will take you to the News Center page, where brief summaries accompany links to each current news story or feature. The News Center is also a gateway to an online library of articles. The **Previous Headlines** link at the bottom of the column brings up a list of stories for the current and previous months. **Articles on File**, at the top of the page, provides access to every article that has been posted on the News Center since it began in April 1998. If you are interested in having an OEM tech brief published in one of our market-focus supplements, click on **Submit a Tech Brief**.

Now click back to the NTB home page and look under Features, just to the right of the news column. At the top, you will find **Tech Briefs** and downloadable **Technical Support Packages**, which are exclusive to the NTB sites. Every tech brief that has appeared in NTB since January 1998 is now available online, listed by category. The NASA Technical Support Packages (TSPs) provide detailed information about the technologies reported each month in NTB. At the end of each tech brief, you'll find the category under which the TSP can be found on the web site. These documents are available free to U.S. citizens and residents, and can be downloaded as PDF files. If you are a new user, you will need to register online (at the top of the TSP page) before using this feature.

If you are not yet an NTB subscriber, you can pause here to **Subscribe** online. If you are intrigued by a hot new product advertised in NTB and would like to find out more, click on **Get More Information...FAST**. The **Reader Forum** invites you to share questions and ideas with colleagues. Those interested in NTB's range of print and electronic marketing tools can review our online media kit by clicking on **Advertise**.

To become an Insider, click on the **Free Newsletter** button to the right of Features. Here, you can subscribe to the *NTB Insider*, an e-mail newsletter that delivers exclusive previews of upcoming NTB articles, advance notice of online and trade-show opportunities, and late-breaking NASA and industry news. We also offer special-focus newsletters covering photonics, CAD/CAE, and test and measurement. Our new **Eguide** feature provides a searchable, interactive database of suppliers, products, conferences, and services. For a relatively small fee, companies can add their own listings to the database.

For access to other NTB-sponsored web sites, scroll down the page to the Connect heading, where you will find links to other sites, including:

Photonics Tech Briefs Online provides industry news and tech briefs on optics, lasers, electro-optics, fiber-optics, imaging, and test and measurement from the *Photonics Tech Briefs* market-focus supplement.

Rapid Product Development Online is an all-digital publication covering tools and technologies for reducing the product design cycle, including rapid prototyping and tooling, mold-making, and advanced CAD/CAE solutions.

Electronics Tech Briefs Online features highlights from the *Electronics Tech Briefs* market-focus supplement, including information on components, systems, software, and board-level electronics.

AFRL Technology Horizons is the online complement to *AFRL Technology Horizons* magazine, from the publishers of *NASA Tech Briefs*, which features cutting-edge technological innovations from the Air Force Research Laboratory (AFRL). If you are not yet receiving this new publication, you can subscribe online.

Across the bottom of the home page, you will find another series of links, including: **About *NTB***, which will tell you more about our magazine's history and what we do; **Links**, which offers connections to sites such as the NASA Commercial Technology Network and the NASA field centers; and **Feedback**, which invites your comments and suggestions. You can also send comments to NTB's Internet editor at suzanne@abptuf.org.

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Reader Forum

Reader Forum is dedicated to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a technical problem, or an answer to a previously published question, post your letter to Reader Forum on-line at **www.nasatech.com,** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864. Please include your name, company (if applicable), address, and e-mail address or phone number.

I am investigating existing ancillary uses of Space Shuttle tile material. I was referred to the August 1996 issue of *NASA Tech Briefs* (Mission Accomplished, page 20) for information on the subject. In particular, I am interested in finding biological applications for this material. Thank you.

Walter Mybeck
wrmybeck@hotmail.com

*(**Editor's Note:** Walter, the article you refer to from 1996 concerned the application of Space Shuttle Thermal Protection System (TPS) blanket material as insulation against heat build-up in a NASCAR Winston Cup race car. Bruce Lockley, TPS Facility Manager at Kennedy Space Center, directed that project. You can contact him for information on other applications for TPS at bruce.lockley-1@kmail.ksc.nasa.gov, or visit the KSC web site at www.ksc.nasa.gov.)*

Technologies Wanted

This month, we feature more abstracts of Demand Pull Technology Transfer projects. These projects identify technology needs within an industry segment — such as Assistive Technology — and find technology solutions to meet those needs. The Rehabilitation Engineering Research Center on Technology Transfer, in partnership with the Rehabilitation Engineering Research Center on Wheeled Mobility, has developed the Wheeled Mobility Project to identify market needs like those described below that represent significant business opportunities. For more details on the project — or to submit technology solutions — visit the project web site at www.rti.org/technology/wheelchairs.

Improved Tires for Manual & Power Wheelchairs

Common tire materials include rubber, polyurethane, composite nylon, and Kevlar-reinforced materials. An ideal tire should have low rolling and turning resistance, while offering high traction on all surfaces. It should be non-marking, maintenance-free, and should allow at least 1,000 miles between service or a one-year life under typical to heavy use. The tire must be electrically non-conductive to eliminate static buildup.

Battery Charger Technologies

Deep discharge wet and gel electrolyte, lead-acid batteries are the standard power source for power wheelchairs. An ideal charger must be about 6 x 4 x 2" in size, and must charge both types of batteries. It must meet or exceed the ANSI/RESNA standard (Part 14) of charging to 80% capacity in 8 hours, while protecting the user from shock. It should alert the user when charge level decreases to 60% of full charge. The charger should cost less than $50 - $70 to manufacture.

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May 15, 2000 - A John Deere model 9600 combine cuts the last crop of barley from Spectrum Astro's new 80 acre site in Gilbert, Arizona.

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Carl G. Ray, Executive Director for SBIR/STTR Programs

Carl G. Ray is the NASA Executive Director for the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs, and is the Source Selection Official (SSO) responsible for their agency-level oversight. Mr. Ray is also the NASA Publications Director for *NASA Tech Briefs* magazine.

NASA Tech Briefs: What are the goals of the SBIR/STTR programs?

Carl Ray: As legislated federal research and development (R&D) set-asides established in 1982 (SBIR) and 1994 (STTR), these programs enable the federal government to tap into the innovation and efficiency of small, high-technology firms. A major goal is to provide opportunities for small businesses to participate in government R&D. Both programs also seek to promote U.S. economic development through private-sector commercial application of government-funded R&D. A specific goal of the STTR program is to encourage small businesses to find and partner with research institutions to develop and transfer innovative technologies. Both programs also promote participation in technological innovation by women-owned small businesses, and by socially and/or economically disadvantaged businesses.

NTB: How do these programs help small businesses grow?

Ray: They provide an entrepreneurial opportunity and support in the form of funding that can reduce the initial risk and expense of serious R&D efforts that are often beyond the means of small businesses, enabling them to compete on the same level as larger businesses.

NTB: How do the programs benefit NASA and the American taxpayer, and what is NASA's FY2000 funding for the programs?

Ray: They furnish an effective resource for the nation's R&D arena, and the U.S. retains the entrepreneurial pool that is critical to meeting its R&D needs. NASA, which has participated in the SBIR program since 1982, continues to report on the expanding contribution of both the SBIR and STTR programs in direct and spin-off technologies, including those that enhance NASA's aeronautics and space programs, improve our environment, advance medical treatment, and increase our ability to manage the "information age."

NASA SBIR funding for FY2000 is $92.1 million; for STTR it is $5.5 million.

NTB: What are some of the major technology areas covered in NASA's solicitations?

Ray: NASA's SBIR Solicitation technology areas (research topics) are aligned with NASA's four Strategic Enterprises: Aero-Space Technology, Human Exploration and Development of Space, Earth Science, and Space Science. The Enterprises are "corporate-like" strategic business units that identify, at the most fundamental levels, unique sets of goals, objectives, missions, and programs representing what NASA does and for whom. Research topics and subtopics are developed and placed in each solicitation, organized according to the Enterprises.

NTB: What is the key to a winning proposal?

Ray: In general, it is the degree to which the idea submitted is innovative, presented with convincing scientific or technical merit, soundness of proposed plans, and potential for commercialization.

NTB: How can newcomers find out more?

Ray: The best way to gain information about the NASA programs in general is through the NASA SBIR/STTR web site at: http://sbir.nasa.gov. The Small Business Administration (SBA) also organizes several national and regional SBIR conferences every year. The NASA centers each have SBIR program offices and Commercial Technology Offices, and information can also be found online at http://nctn.hq.nasa.gov/directory/index.html.

A full transcript of this interview is available at www.nasatech.com. Mr. Ray can be reached at cray@mail.hq.nasa.gov.

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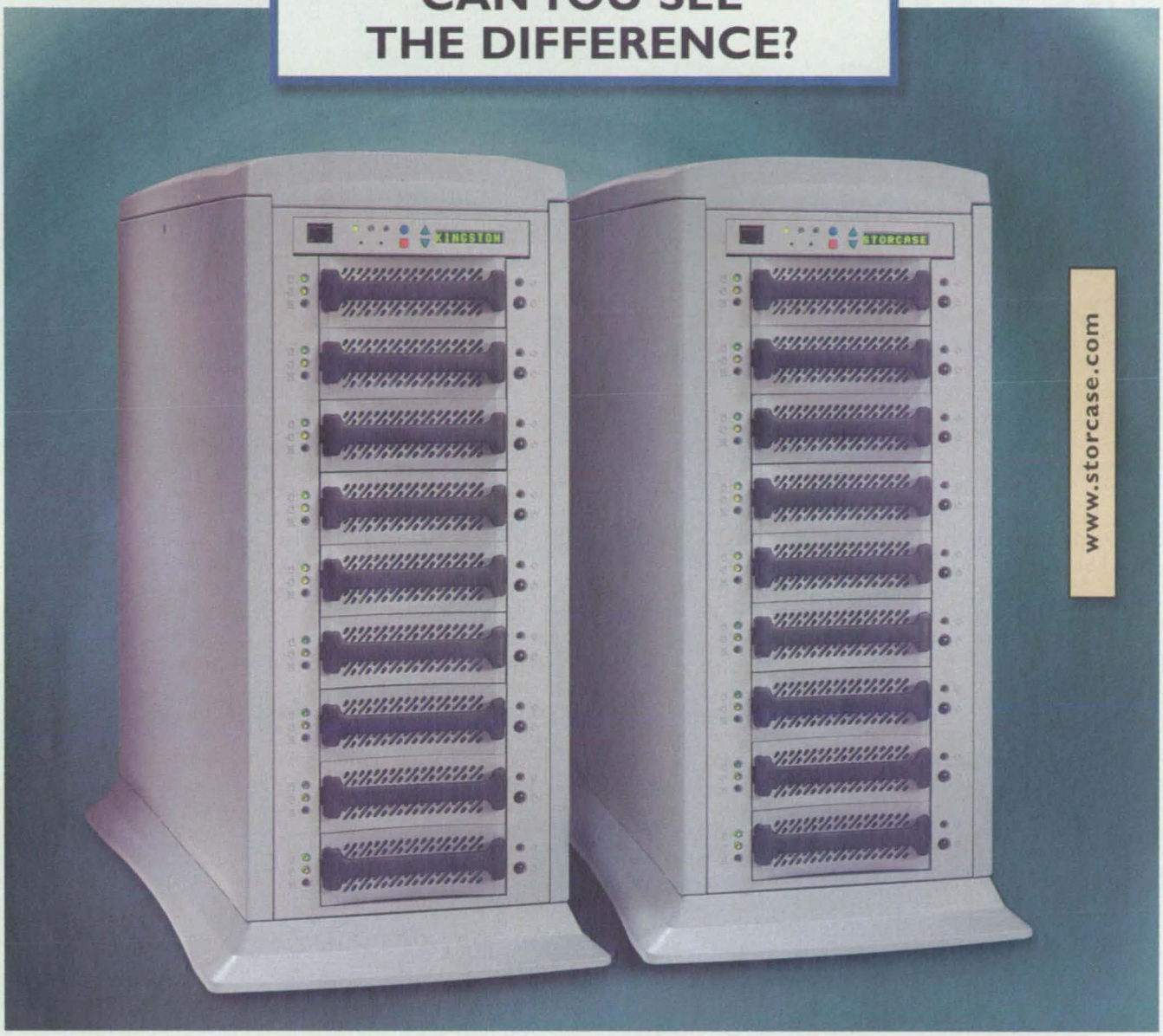

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Maple 6: The Analytical Engine

Steven S. Ross

Over the years, Maple has become somewhat of a standard for equation processing. Like Mathcad, TKSolver, and *Mathematica* — among many other packages — it allows users to enter formulas in common math notation, and it allows output in numeric or graphical forms. But its polished interface and range of math functions will be compelling for many users, especially when data must be calculated super-carefully.

Maple (from Waterloo Maple, Ontario, Canada) starts with more than 3,000 functions built in. There's plenty of flexibility for solving everything from linear algebra (including vector math), to calculus and differential equations. Iterative and recursive programming is also fairly easy, using Maple's FORTRAN-like programming language. Users familiar with common languages such as C, BASIC or Pascal should have little difficulty navigating in Maple.

Maple 6 offers big improvements over earlier versions in interoperability — you can even run it inside Excel 2000.

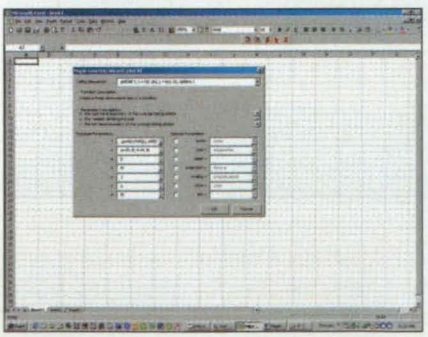

Figure 1. The entry screen within Excel. Note the mandatory defining of plot limits.

You also can link external libraries of legacy code to programming done in Maple's own language. And, you can export Maple work in RTF (rich text format) to Microsoft Word and other word processing programs. Maple 6 also uses the Numerical Algorithms Group (NAG) solvers — more than 100 functions were added to Maple's linear algebra package to use them.

Maple has long allowed users to specify the number of decimal places needed in answers. A dirty little secret was that the computational methods were not entirely standard. Now all floating point computations are IEEE 754 compliant.

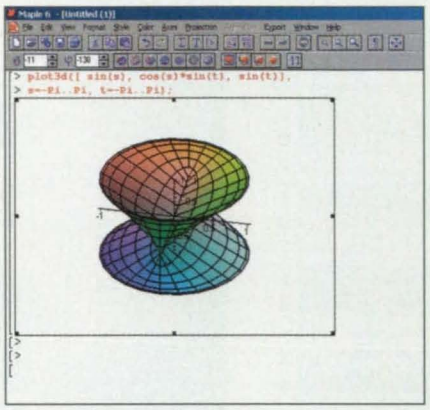

Figure 2. The same function as in Figure 1, done directly inside Maple 6.

In operation, you can use Maple as a fancy calculator — entering actual values into the function you specify. But as with spreadsheeting and programming, it usually is preferable to enter symbols and then assign values to the symbols. A little bit of extra typing provides reusable functions and results that are easier to audit. If you specify floating point computations for even one variable, the IEEE standard requires that all variables calculate to the same precision. This can slow things down. But Maple's calculation engines are quite fast anyway. Unless you are running big matrix problems, or find that speed has become an issue, don't worry about fine-tuning.

Once you have Maple, you keep thinking up things for it to do. During the review period, I started using it to convert among decimal, hex, and binary notations (BASIC wants base 10, while HTML wants hexadecimal notation). The function is "convert (base-10 number, base, n)." There also are about 30 Gaussian integer functions, a whole statistics package, and a set of financial functions.

The Excel link is not perfect, unfortunately. It works well if you are careful to get your input right in the first place (Figure 1). If you make a mistake, however, you get a cryptic error message — it is dumped into a cell in the spreadsheet. In Excel, you can't go back and touch up a bad entry screen, either. You can try to fix the mess in Excel's formula bar, but only the most obvious typos will be trackable. You probably will have to enter the whole function again. For graphical-output problems, that's a particular chore because there's so much to fill in. You should be able to recall offending data entry screens.

The moral: Do your prototyping in Maple itself (where there's less to fill in, you can touch up your work, and you benefit from good error-handling) and leave the Excel link for feeding data tables into Maple-developed functions.

Why Maple over other competent products in the same or overlapping categories? I've often thought of Maple as the tool for techies who are really serious about understanding the math they use. There's even a "simplify" command that cleans up redundancies in sloppy expressions, and a "factor" command that factors polynomials. They're great for getting to the bottom of expressions and really understanding what's going on. It is no wonder the package is used to

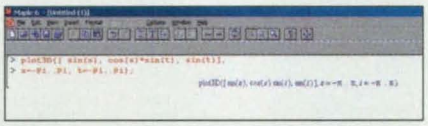

Figure 3. The same function, with a minor typo — "plot3D" instead of "plot3d." Users get used to the non-action in these cases and hunt for errors. But there's no message to guide them. Note that the system, by default, generates a "standard notation" version (blue) from the "Maple notation" that was entered. You could also enter in standard notation.

teach calculus and differential equations at many colleges. Also, Maple graphics are first-rate. That's one reason to use it inside Excel in the first place. You can supplement, or supplant, the ugly, bug-ridden Excel standards.

Maple is available on many platforms, including Windows (DEC Alpha chip as well as Intel), Macintosh, and many UNIX variants. We reviewed in Windows 98 and NT on machines as slow as 200 MHz with 64 MB of RAM running fairly large problems. The program is responsive even on these older boxes. The US single-user retail price is $1,695; multi-user and upgrade pricing is available at www.maplesoft.com.

Steve Ross is an associate professor of professional practice at Columbia University's Graduate School of Journalism, where he runs the science writing program and teaches analytical journalism.

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Commercialization Opportunities

Portable ECG/EGG Data Recorder

A portable electronic unit monitors and stores 48 hours of myoelectric activity of the stomach and heart. The unit can be readily worn on a belt or fastened to clothing in other ways so as not to interfere with normal activities.
(See page 30.)

System Locates Lightning Strikes to Within Meters

This system, using at least three receivers to record electric-field and acoustic measurements, can locate lightning strikes with significantly greater accuracy than earlier systems that could produce errors of more than 0.5 km.
(See page 38.)

Flip-Chip W-Band Amplifier: a Prototype of Q-MMICs

Bump bonding a high-speed, low-noise HEMT onto the passive portion of the amplifier circuit on a GaAs substrate results in an economical alternative to MMIC. Savings are realized via better use of cheaper substrate areas, easier mixing and matching, reduced complexity, and hybridizing the best-available active devices with passive circuits.
(See page 40.)

Automated Apparatus for Testing Gyroscopes

A computer-controlled apparatus called Gyroscope Automated Testbed is designed primarily for testing vibratory gyroscopes; however, by changing the interface circuitry, one can test nonvibratory gyroscopes and other devices that can be subjected to noise analysis.
(See page 48.)

Enhanced Shield Against Meteoroids and Orbital Debris

A "stuffed Whipple" shield is a lightweight, inexpensive alternative to simple aluminum meteoroid/orbital-debris shields. The new shield increases protection against hypervelocity impacts, without significantly affecting spacecraft design. This design could be of interest to developers of armored structures and vehicles.
(See page 54.)

High-Performance Zn Anodes for Ag/Zn and Ni/Zn Cells

This invention will increase the usefulness and decrease cycle-life costs of Ag/Zn and Ni/Zn cells in NASA Space-Station-support applications. Batteries with increased energy density and longer cycle lives are always of major interest to manufacturers of electronic consumer products and portable medical and military equipment, among others.
(See page 56.)

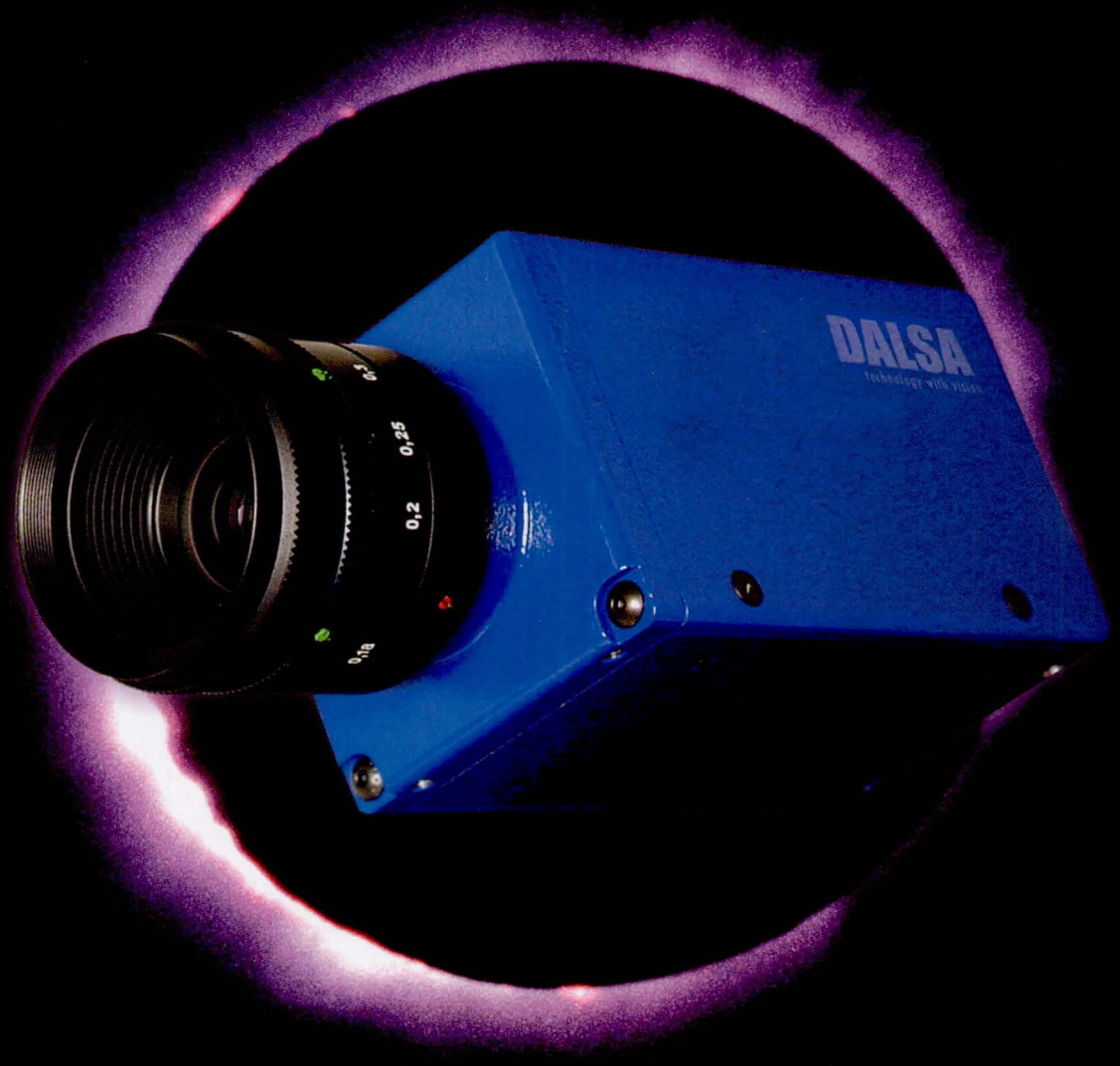
Mechanism for Planar Manipulation With Simplified Kinematics

The improved robot mechanism results in simplification of kinematics, which in turn, results in reduced computational burden in controlling the manipulator.
(See page 58.)

July 2000

PHOTONICS Tech Briefs

PHOTONICS SOLUTIONS FOR THE DESIGN ENGINEER



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Supplement to *NASA Tech Briefs'* July 2000 Issue Published by Associated Business Publications

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On the cover: *Dalsa Corp.'s Eclipse Camera, which the company calls the world's most responsive linescan camera. The Eclipse is 100 times more responsive than today's standard linescan cameras, according to the company.*

Photo courtesy Dalsa Corp.

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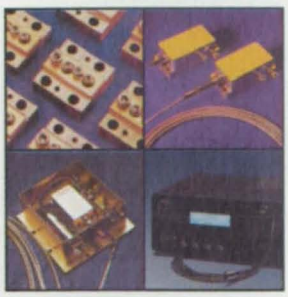

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Eighty-seven scholarships and grants totaling $220,000 were approved for award by SPIE's Board of Directors at the 1999 Annual Meeting in Denver, and the process will be repeated again this month at the 2000 Annual Meeting in San Diego. Last year's amount was augmented by $30,000 in student travel contingency grants, awarded throughout 1999 for students in need of travel assistance to present papers at SPIE conferences.

Application forms are now available via the SPIE web at www.spie.org/web/courses/schol.html, or by writing to the SPIE Scholarship Committee, PO Box 10, Bellingham, WA 98227-0010, USA, or by sending your request to education@spie.org. The annual deadline for application submission is March 31, 2001.

Information and application forms for the Student Travel Contingency Grant are available via the SPIE web at www.spie.org/web/courses/schol.html#grants, or by sending your request to studenttravel@spie.org. All information and an application form detailing your need for funds must be submitted no later than 10 weeks prior to the first day of the SPIE symposium to which you wish to travel.

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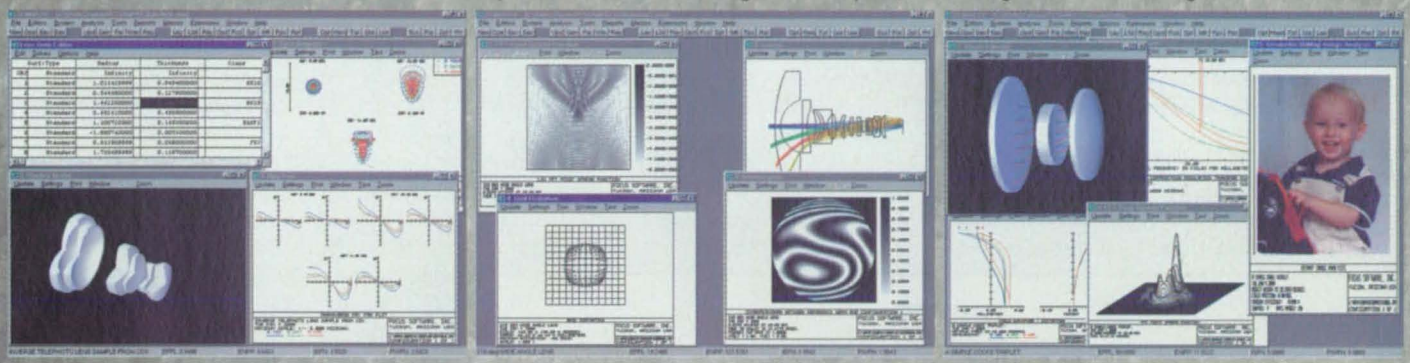

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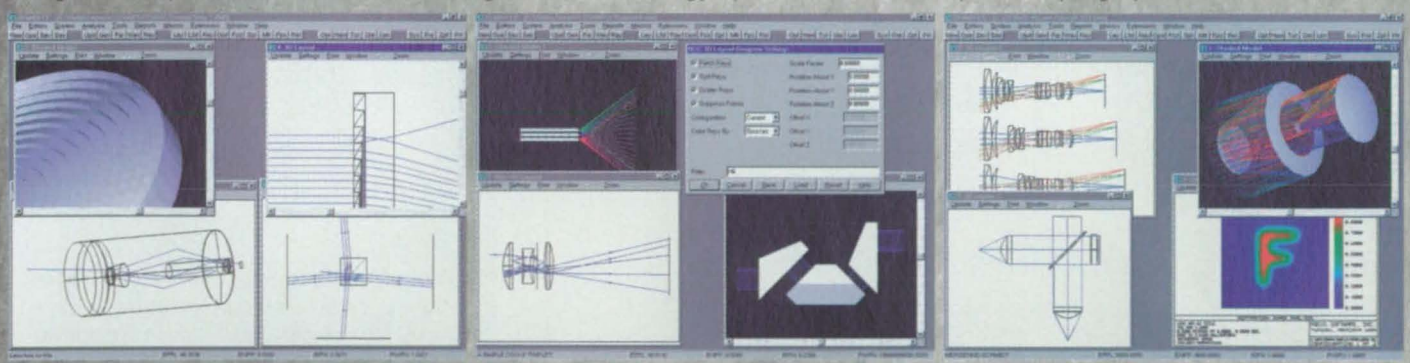

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Lasers in On-Line Process Control

Quality-assurance applications increasingly call upon lasers from Spectra-Physics and others.

Process control and on-line QC/QA applications place stringent demands on laser performance, especially on its output stability, reliability, and short mean time to repair (MTTR). The latter factor is especially important because production-line down time often represents a far greater portion of the total cost of ownership for process-control machinery than the equipment's original purchase price. To this end, laser manufacturers have continued to enhance and optimize established laser technologies, as well as develop entirely new design concepts. This article examines two representative on-line QC applications and briefly reviews some of the significant laser advances that have contributed to their success.

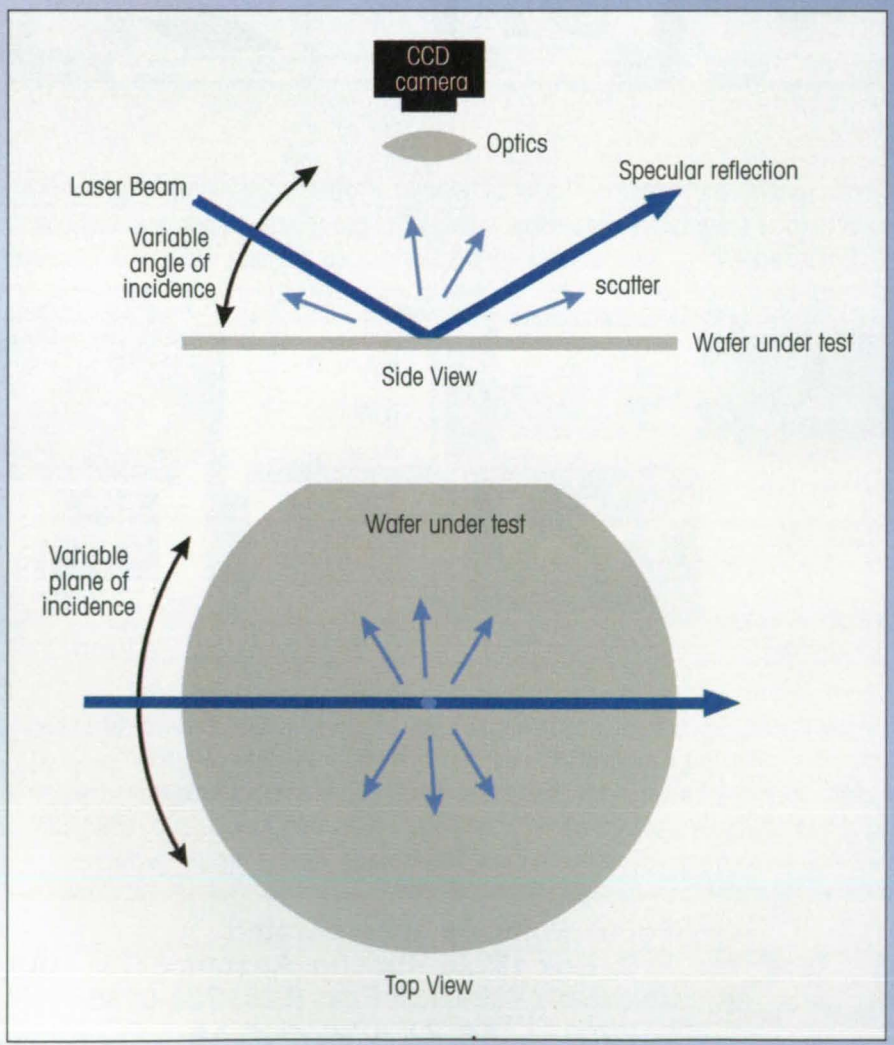

Figure 1. Schematic of the optical system used for darkfield wafer inspection.

Darkfield Wafer Inspection

Darkfield wafer inspection is used for detecting submicron-sized defects and particulate contaminants at several points in the fabrication of semiconductor wafers. The technique is particularly useful as an adjunct to chemical mechanical planarization (CMP), which involves using a polishing pad and abrasive slurry to planarize the wafer. CMP delivers better planarization than prior technology, enabling the production of circuits with a larger number of layers. Unfortunately, CMP can scratch the wafer, as well as leave behind residue from the polishing slurry.

In a darkfield inspection system produced by Inspex of Billerica, MA, a laser illuminates a small area of the wafer under test from an oblique angle. Collection optics and a CCD camera, placed perpendicular to the surface of the wafer, are used to detect any scattered light (Figure 1). In the absence of any defects, all the light is specularly reflected, and nothing reaches the camera. A defect-free wafer therefore appears completely dark to the camera. Any scratches or contaminants will scatter some of the laser light into the detection optics, causing them to appear as bright features. By automated translation of the wafer, the entire surface can be rapidly inspected.

Once the wafer has been patterned, periodic circuit structures will diffract the laser light, and can also show up as bright features. There are several techniques for distinguishing this diffracted light from the light scattered by defects. The most flexible and effective of these is to adjust the illumination geometry so as to direct the brightest diffracted orders away from the collection optics. In the Inspex in-

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strument, this is accomplished by varying the laser's angle of incidence (altitude), as well as by rotating the plane of incidence (azimuth).

The source for this application was developed by Spectra-Physics Lasers, in cooperation with Inspex, specifically to meet the needs of darkfield wafer inspection. The result was a frequency-doubled (532-nm) diode-pumped solid-state Nd:YVO_4 laser, which delivers 200 mW of continuous-wave output power in a TEM_{00} beam (M^2<1.1).

All cavity optics in this laser are mounted on a monolithic I-bar structure: this approach delivers excellent mechanical rigidity and makes optical alignment insensitive to temperature changes. The entire cavity itself is completely sealed to prevent outside contaminants from entering. The total elimination of epoxy adhesives or rubber seals within the laser prevents internal contamination from outgassing. The result is a laser that never needs cleaning or adjustment of its cavity optics.

MTTR is minimized in this design by locating the pump lasers in the power supply and coupling them into the laser head via fiber optics. This enables diode replacement to be performed without disturbing the optical alignment of the laser head. This is very important in the Inspex system, which requires accurate alignment of the laser beam with the instrument's optics. Extended lifetime and reliability are insured by running the laser diodes at derated levels. Testing has proven that after 18,000 hours of operation less than 8 percent of laser diode current headroom has been consumed (Figure 2).

Food Sorting

Sorting is used throughout the food industry to eliminate spoiled products, unwanted plant or animal parts, and foreign objects. Typical examples include separating shrimp meat from peel, legs, eyes, and heads, and sorting nut meat from shells. Barco Machine Vision of Aarschot, Belgium, is a leading producer of automated sorters for the food, recycling, tobacco, and textile industries. Their equipment utilizes a wide variety of illumination and vision technologies, such as CCD cameras, x-rays, LEDs, and lasers.

Figure 3 shows a simplified schematic for a typical laser-based sorter from Barco. The product to be examined falls in a wide, thin sheet from a vibrating platform or conveyor belt. A rotating polygon scanner sweeps one or more laser beams perpendicular to the direction of product motion. The combination of rapid beam raster scanning and product motion enables all of the product to be sampled. A second identical optical system is used to view simultaneously the other side of the product stream.

Beamsplitters and other optics separate off light returned from the product, which is then split into three separate beams and sent to detectors. The first detector looks at the center of the returned beam, the second blocks the center and looks at the periphery of the returned light, and the third detects all the returned light. By combining and comparing the output from these detectors, the system can differentiate specular reflection from scattered light.

The intensity of the specular reflection provides information on the color of the product. This enables the system, for example, to differentiate a French fry with a dark spot on it from an unblemished one. The intensity of the scattered light enables the system to sense differences in texture, even in the absence of a color difference. This, then, might be used to separate a white rock from a white bean. Once an unwanted

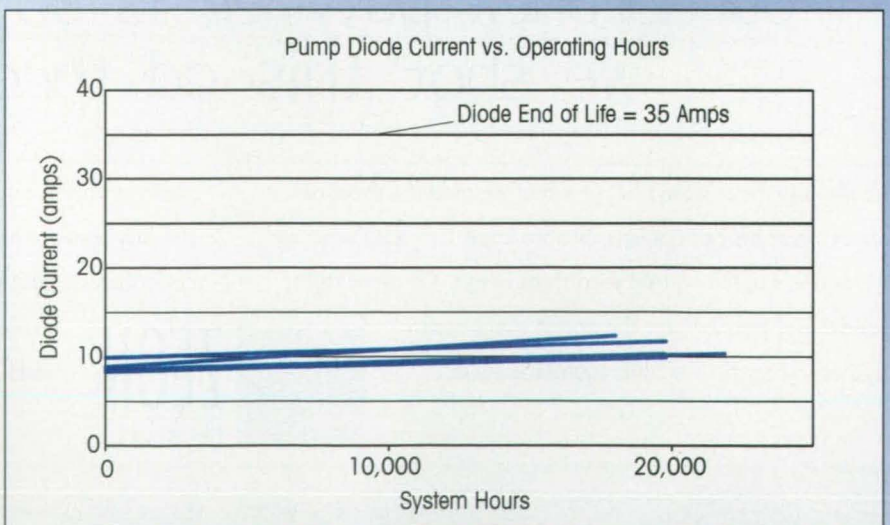

Figure 2. Test data for J20-MG-532C lasers show that after 18,000 to 23,000 hours of operation the pump diode lasers are still far from their end-of-life current of 35 A.

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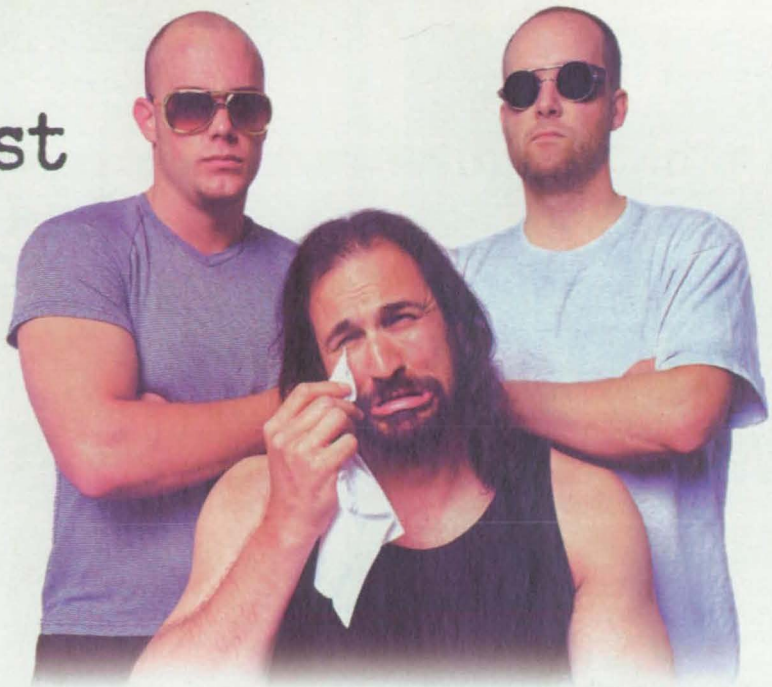

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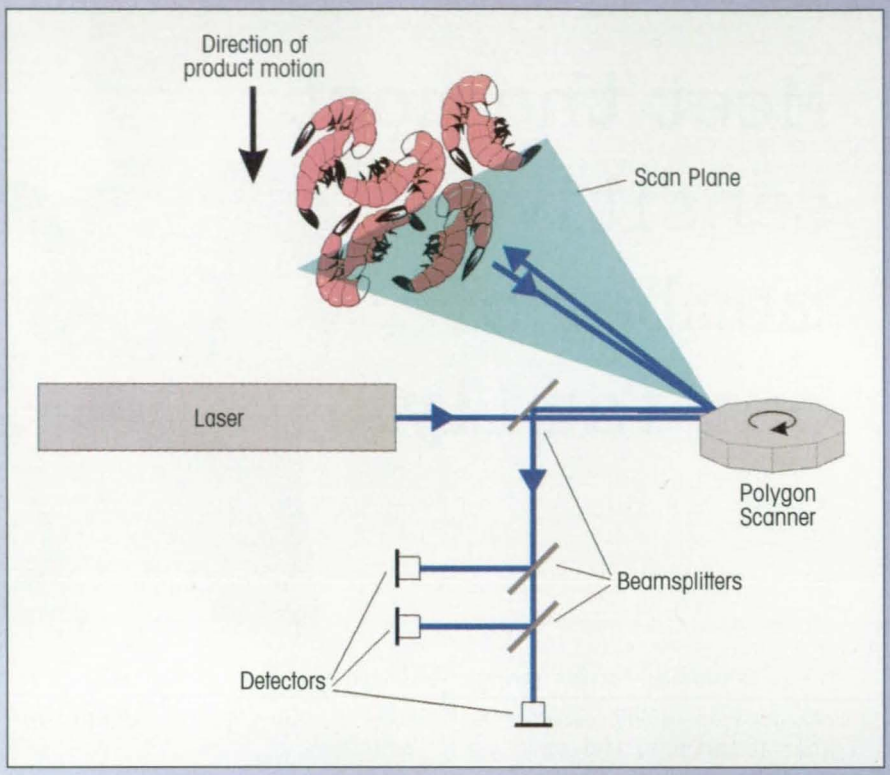


Figure 3. Schematic of the optical system used for food sorting.

object is identified by the system, it is blown out of the product stream with an array of air nozzles.

Multiple lasers at various wavelengths can be used to allow the detection of several different colors. Multiple beams must be rendered colinear through the use of dichroic filters before entering the scan optics; colinearity is necessary to insure that each laser is examining exactly the same point.

The first step in selecting a laser source for food sorting is to determine the wavelength required to make the necessary color differentiation. After wavelength, the most important parameters are output stability, beam quality, and reliability. Output stability insures consistent measurement, and beam quality is required to maintain the proper focused spot size.

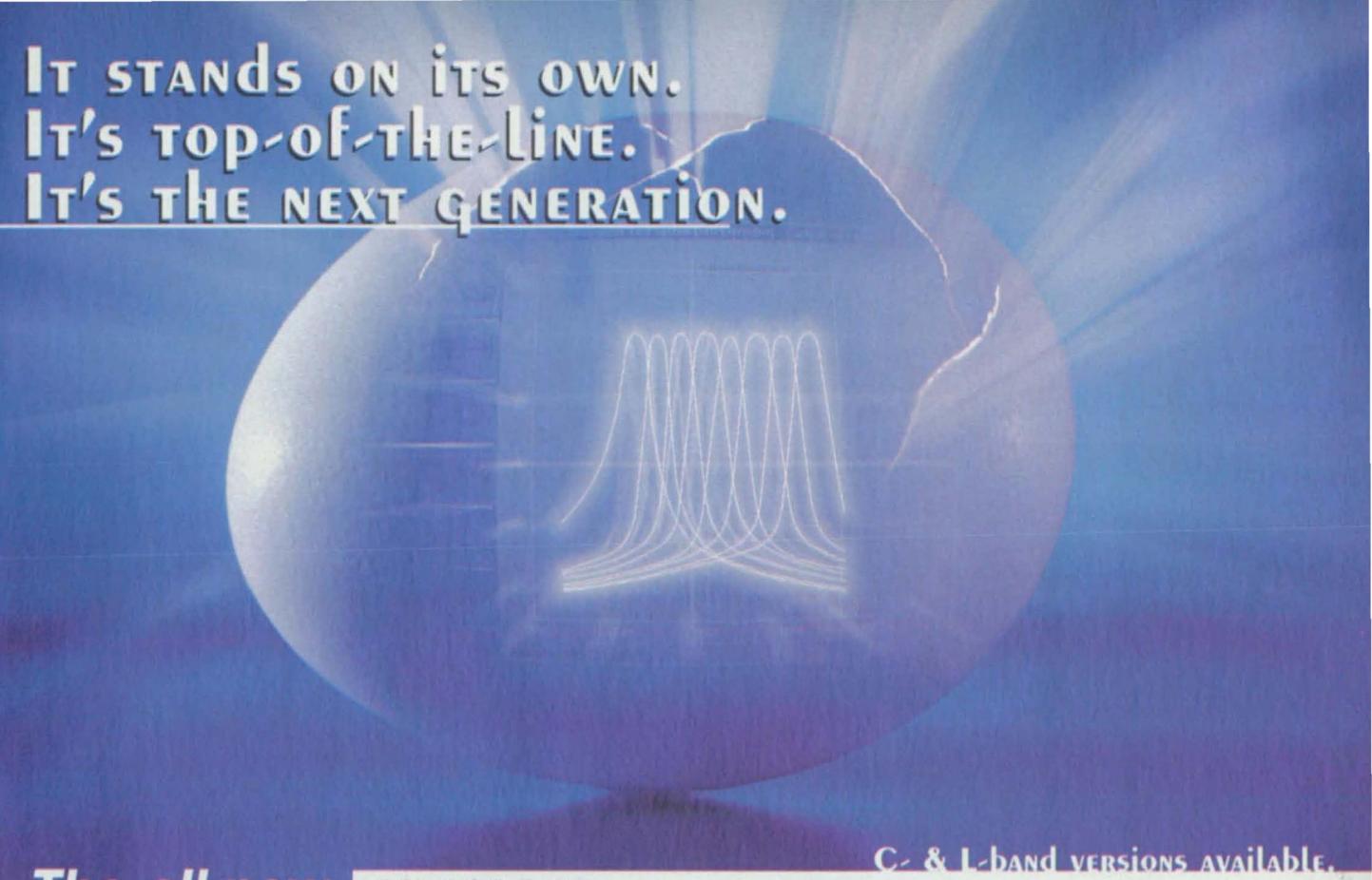
The air-cooled argon ion laser has proved to be an advantageous source for Barco, for many reasons. It can simultaneously supply two wavelengths (488 and 514 nm) that cannot be obtained from any other source, and that are perfectly colinear, thus eliminating the need for beam-combining optics. Argon ion lasers also provide the requisite amplitude stability, noise characteristics, beam profile, and polarization characteristics.

The air-cooled ion laser currently being supplied by Spectra-Physics for this application has also been specifically engineered for long lifetime, typically performing within specification for an average of 10,000 hours. These lifetimes have been achieved through the use of high-efficiency mirror coatings, which allow efficient operation with a low tube current.

Spectra-Physics has also designed this laser to minimize MTTR. The most involved repair task involves putting a new plasma tube into the laser head. These tubes are prealigned at the factory and precisely positioned in the head in the field using locating pins. Thus only minimal system realignment is required after tube replacement.

Maturing laser technology has resulted in products with the reliability and performance characteristics necessary to meet the rigorous demands of many on-line process control and inspection applications. Continued development of more rugged and long-lived lasers, especially based on all-solid-state technology, promises to push the laser into ever more diverse uses.

The authors of this article are Michael Watts, product manager, OEM business unit, and Donna Berns, marketing manager, commercial lasers division, Spectra-Physics Lasers Inc.; Joe Danko, vice president of R&D and engineering, and Rob Simpson, director of sales and marketing, Inspex; and Johan Calcoen , R&D optics manager, and Marc van Gerven, marketing manager, Barco Machine Vision. For more information contact Watts at Spectra-Physics Lasers, 1305 Terra Bella Ave., Mountain View, CA 94043; (650) 966-5761; mwatts@splasers.com; or Berns at (650) 966-5808; dberns@splasers.com.



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For More Information Circle No. 493

IEEE 1394 Invades the Industrial Realm

The high-performance serial bus lifts bandwidth and simplifies connectivity.

Its official name is IEEE 1394. It is also called FireWire® by Apple and i.LINK® by Sony, which has licensed this name to several other companies. It was created in the late 1980s as a digital technology designed to satisfy the ever-increasing demand for communications bandwidth for video. It was also designed to simplify and reduce the number of cables and connectors between devices. Simple one-cable connectivity has become a necessity brought about by miniaturization and increasing device functionality as ports have been reduced in size and number.

The IEEE 1394 high-performance serial bus has already found its way into consumer products and one day probably will link every digital appliance in the house: TV, DVR, camcorder, high-fidelity stereo, computers, and peripherals. Now it is poised to make the same impact on the industrial/scientific imaging world.

Guaranteed Bandwidth, Guaranteed Delivery

IEEE 1394 offers high-speed, bidirectional transfer of high-volume digital data. It moves up to 400 Megabits/second of data, for applications requiring guaranteed bandwidth (isochronous mode), such as the delivery of video streaming images in real time, or guaranteed delivery (asynchronous mode) for the transfer of content-critical commands and file transfers that are not time-sensitive. Data transfer speeds are expected to double this year, with a top rate of up to 800 Megabits/second. Rates of up to 1200 Megabits/second are anticipated for next year.

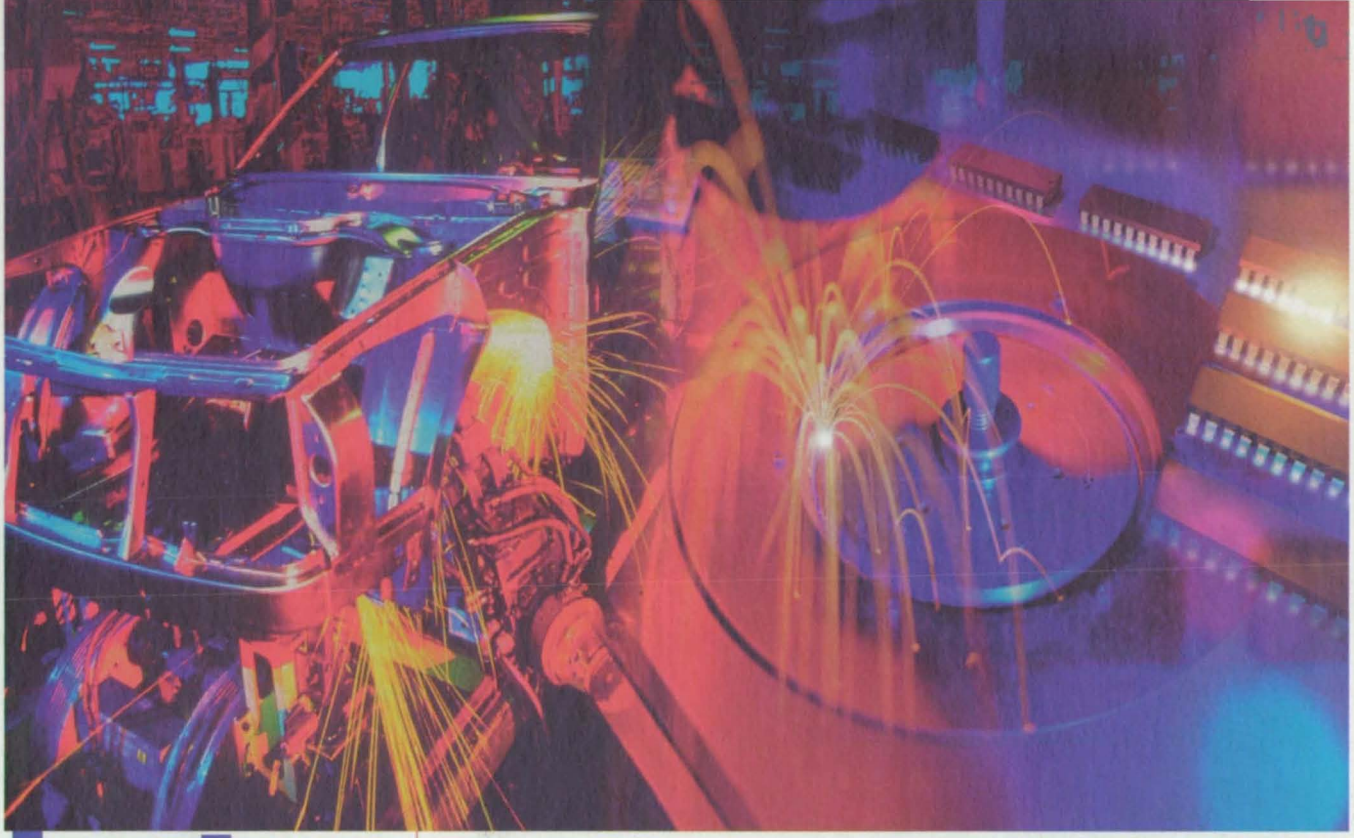
IEEE 1394 is flexible and can be used with "tree" or "star" network topologies, connecting multiple devices together in a dynamic unsupervised network. Devices can be linked by low-cost serial cable with inexpensive four- or six-pin connectors. IEEE 1394 allows for cable lengths up to 14.8 feet and up to 236.1 feet between devices. Up to 16 hops are allowed between any two devices, and up to 63 devices can share the same bus. A single network can accommodate up to 1024 buses and 64,512 devices.

IEEE 1394 enables dynamic unsupervised bus management by facilitating automatic nonmanual bus configuration and reconfiguration. This includes automatic address selection and hot connect/disconnect of devices without loss of data. If a device is added or removed from the network, there is no need for the system to reboot, and there is no need for ID switches. Communications within the network are peer to peer; there is no need for a computer, just a bus manager on the network. The network can handle multiple CPUs and such devices as cameras, printers, CD-ROM drives, hard drives, and other storage devices, greatly enhancing flexibility and ease of maintenance.

Speed plus Bandwidth

IEEE 1394 supports bidirectional data transmission at speeds of 100, 200, or 400 Mb/s (megabits/second), or approximately 10, 20, and 40 MB/s (Megabytes/second). Future planned transmission rates are 800 Mb/s (80 MB/sec) and 1.6 Gb/s (160 MB/s). By contrast, the common USB (universal serial bus) 1.0 interface only supports about 1.2 Mb/s. The SCSI (small computer system instruction) interface supports a small number of devices on the network while providing data transfer at 5 to 30 MB/s with large, expensive cables and connectors. Traditional video interfaces such as SDTI and RS-422 support rates of approximately 25 MB/s and 1 to 16 MB/s respectively. SDTI and RS-422 also have the disadvantage of utilizing large, expensive connectors, and have limited network-

Sony has adopted the IEEE 1394 serial bus for several of its industrial cameras, including the DFW family shown above: from left, the DFW VL500, the DFW V500, and the DFW V300.



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ing capability. On the horizon are interfaces such as USB 2.x and Channel Link™. USB 2.x has limited networking capability and is computer-concentric, supporting speeds of approximately 30 MB/s. Channel Link, the fastest of these interfaces, supports 100 MB/s, but has no networking capability—it is strictly a point-to-point connection—and it requires four or five pairs of cables and connectors to link devices. Channel Link is a very specialized connection, one usually used in video applications.

The bottom line is that the IEEE 1394 interface supports more bandwidth, flexibility, reduced cabling, and lower costs than anything on the market today.

In 1995, 1394 was officially adopted by the Institute of Electrical and Electronics Engineers (IEEE) as a high-speed digital interface among audio/video products, personal computers, and peripheral devices. It has also been adopted as a standard by the Digital Audio Video Council (DAVIC) for home networks. The Digital Video Broadcasters (DVB) and the Electronics Industry Association (EIA) have also adopted 1394 for digital broadcast receivers. In addition, IEEE 1394 is gaining rapid acceptance in the industrial and scientific arenas.

Sony and IEEE 1394

Because Sony saw IEEE 1394's potential immediately, the company joined the IEEE 1394 Trade Association in 1994. There are many working groups within the trade association that are developing standards for digital cameras for industrial markets. For example, DCAM® Version 1.2 defines specifications on how 1394 cameras should work. It has evolved to support new triggering, partial scan interfaces, a wider range of operating systems, and connectors.

IEEE 1394 is graduating from theory into practice in the world of imaging. IEEE 1394 cameras are now used in videoconferencing, photo kiosks, multimedia, and ID badging and machine vision/scientific applications such as laboratory analysis and inspection systems. Among consumer products, it is nearly a standard for most digital camcorders and personal computers. IEEE 1394 has spawned the consumer acceptance of PC-based DV home editing.

This year Sony introduced two digital eight-bit monochrome 256-grayscale cameras specifically designed for high-resolution machine vision and scientific applications. The Sony XCD-SX900 camera delivers uncompressed

video image output of 1.45 million pixels (1280 × 960) at 7.5 frames per second, for use with microscopes in applications such as semiconductor inspection. The XCD-X700 delivers 0.8 million pixels (1024 × 768) at 15 frames per second and is suitable for digital inspection of high-end machine vision applications such as the manufacture of auto parts.

Both cameras employ half-inch progressive scan CCD sensors with square pixels. These cameras also have a partial-scan function that allows output selection of a smaller rectangular portion of the full image to increase the frame rate or reduce processing time. This is particularly valuable in scientific applications, where only part of the image needs to be captured before moving to the next image.

The "one cable" 1394 connection links the camera to a computer for all image transfer, camera control and status, and power. In fact, multiple cameras and compatible devices can all be connected via the IEEE 1394 bus to further extend the camera's suitability for machine vision and other industrial applications.

Into the Future

IEEE 1394 technology has brought digital bandwidth, capability, and cabling/cost savings to the high-resolution imaging market. Like Sony, other companies have brought increasingly powerful, feature-rich cameras to the technology. Now very high-resolution IEEE 1394 cameras, such as the new Sony XCD series, have the capacity to capture an entire detailed image (or a reduced field image) and send it to any other device on the network—PC, printer, storage device—in one pass, thereby eliminating the need for framegrabbers, add-in boards, or multiple passes to assemble a complete image from several smaller fields. These cameras can be externally controlled and linked to other devices or to each other.

The "glue" that brings PCs and 1394 digital cameras together is software. Matrox and National Instruments are two pioneers of application-oriented software designed to enable users to take advantage of the remote control capabilities needed to set up machine vision or laboratory analysis systems. Windows® 2000 software is designed to offer complete 1394 support (Windows 98 software offers partial support, primarily for videoconferencing functions). Other vendors are sure to follow Microsoft's, Matrox's, and National Instruments' lead. As 1394 gains wider acceptance in nonconsumer applications, more off-the-shelf application-oriented software is expected.

As of this writing, IEEE application-specific software development has not yet caught up to high-end industrial/scientific hardware, such as the Sony 1394 cameras. The user will need to work with available off-the-shelf software solutions, or seek out a consultant or fellow early adopter to create an application-specific high-resolution digital imaging solution.

Because 1394 is so new to the high-end imaging marketplace, these consultants are still relatively few in number. With the introduction of Windows 2000 and more application-specific 1394 software, this situation should reverse itself.

Like many new technologies, IEEE 1394 imaging technology in the machine vision/scientific arenas may at present be the province of users who demand a digital solution, who need digital imaging for specific applications, or who may want to try it just to "get their feet wet" with a prototype while waiting for the next generation of improved devices and shrinking costs.

That next generation is not far off. As was said above, Windows 2000 software offers full IEEE 1394 support, and other software vendors are following suit. In all likelihood, 1394 adoption will mirror the development of the Internet: as a technology comes of age and the marketplace gains critical mass, hardware and software manufacturers will rush to support it.

The benefits of IEEE 1394 are clear. In the high-resolution industrial imaging world, they translate into improved image capture and data transmission capabilities, both in sensitive real-time applications, such as video streaming or high-end machine vision inspection, and delivery-sensitive applications, such as microscopic and scientific inspection.

Clearly the world is going digital, and the machine vision/scientific imaging world will follow. How long before this happens? It is hard to say. But one thing emerges clearly: in the industrial and scientific arenas, the IEEE 1394 serial bus is the bandwidth of the future.

This article is based on a white paper delivered by Jerry Fife, product manager, Visual Imaging Products, Broadcast and Professional Company, Sony Electronics Inc. at SPIE's Photonics West 2000 conference. For further information on Sony imaging products, contact Sony Electronics, 1 Sony Drive, Park Ridge, NJ 07656; phone 1-800-686-SONY.

Arizona's Clusters as a Model

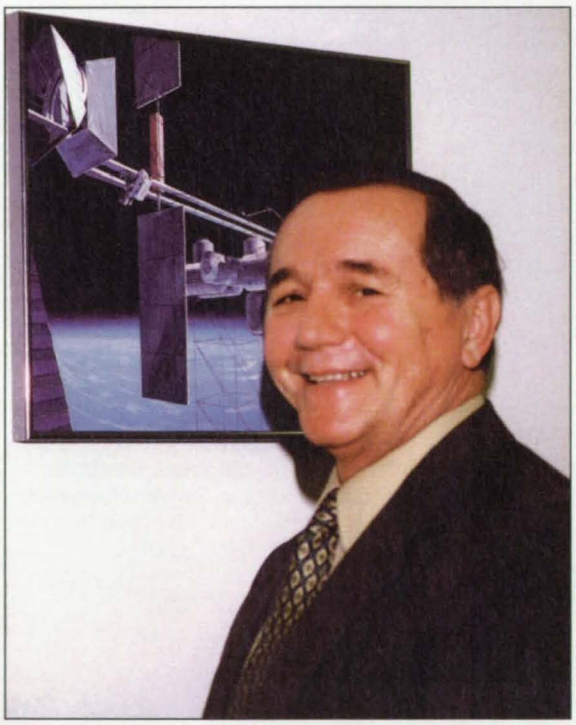
By Robert Breault

In the first installment of this series ("The Evolution of Structured Clusters," *Photonics Tech Briefs*, May 2000, page 10a), I offered a definition, as follows: "A cluster is a concentration of firms across several industries that creates quality jobs, exports goods and services, shares common economic foundational needs, and unites the public sectors of economic development, legislatures at all levels, universities, community colleges, the K-12 educational community, workforce development, support foundations, and all community economic stakeholders."

As an example I cited the State of Arizona's efforts to create a structured cluster—that is, one that did not grow in organic fashion but was created by a known and intentional process. Arizona has eleven interactive industry clusters, and a structured set of seven foundations to support the clusters.

The Arizona economic development plan addressed three basic questions.

- The first is, what should be the goal of economic development? (My expansion of the original response is in italics.) The goal of economic development is to increase the standard of living and enhance opportunities for advancement by increasing per capita real wages, creating quality jobs, fostering enterprise, and improving the quality of life. *The goal of economic development at the national level for regional industry clusters is: to increase, in a catalytic way, their members' access to capital; develop and share market information; and enhance opportunities for the expansion of their regional cluster of industries. The latter could be done by fostering enterprise growth, improving regional infrastructure, enabling public and private meaningful dialogue, removing national legislative barriers, and improving the overall economic health of the region.*
- What are appropriate strategies for economic development? Economic development strategies create quality jobs by attracting, retaining, and nourishing value-added clusters through initiatives that strengthen economic foundations.
- How should regions and nations organize for economic development? Public-private partnerships are required to both strengthen foundations and promote cluster-based economic development.



The planners proposed a three-phase approach. (My suggestions for the optics industry are again in italics.)

Phase 1: Strategic Assessment. An economic framework based upon "best practices" from across the nation was used to prepare an in-depth strategic assessment of the needs of the region. *A national strategic assessment would undoubtedly reveal that the aerospace, biomedical, telecom, environmental, optics, and software industries, for instance, are some of our nation's strongest economic assets of the future. You may ask, why perform an assessment if we know the answers? Because we do not know all the vital cycle industries, nor do we appreciate their magnitude and impact. I cite today's optics industry as the foremost underrated key industry in the United States. In other countries, it may be the same or different industries: forestry, oil, hydroelectric power generation, etc.*

Phase 2: Strategic Planning Process. In a statewide planning process involving a broad spectrum of Arizonans, the strategic assessment was used to develop initiatives. *This process will be a major challenge at the national or global level. At the state level, frequent meetings required individual participation. Individual participation was the soul of the plan because the planners got first-hand input from the consumers of the output — private companies. The initiatives were not the ideas of the planners but came from the people in the marketplace. Nationwide individual input from companies, involving frequent attendance at meetings, is unlikely. The clusters may be the solution for getting "direct" input from CEOs and other company executives at the local level, an opportunity that is presented by national gatherings of clusters. Arizona initiated the first of such meetings in June 1995 at the North American Cluster Conference. The interest in clustering was so high that it even surprised the planners. Before any invitations were sent out for the 75 seats available, there were more than 200 requests for them. The Competitiveness Institute now sponsors an international cluster conference annually. The Coalition for Photonics and Optics (CPO) is another example of a national response effort.*

Phase 3: Implementation. Specific strategies developed in the planning process are being implemented through specific public- and private-sector actions. *The implementation phase is most often the hardest. It requires buy-in and participation by industry leaders. This is taking Total Quality Management to a global scale. It leaves the dri-*

vers for growth in the local region, but takes the development of the infrastructure to a national or global level of partnership.

The optics community has to acknowledge that it has no plan for the economic development, growth, and support of its industry. We have no national SIC or SOC codes, and little or no market analysis, metrics, or demographics for our industry. Supportive legislators and interested investors find it hard to measure the size, value, and potential growth of the optics industry. Fragments of such information would indicate that investors and public-sector figures should be paying much more attention to our high-growth industry.

The Arizona Strategic Planning for Economic Development (ASPED) study reflected contributions by every segment of Arizona's diverse population and every region in the state. The top ten economic development concerns of ASPED participants were:

- education;
- capital availability;
- work-force opportunities/ development;
- interorganizational coordination;
- infrastructure;
- business climate;
- business retention/expansion;
- rural concerns;
- structure of economic base; and
- leadership.

After reading studies from other optics clusters, I conclude that it is reasonable to expect that these concerns permeate all clusters at the national level.

The Arizona cluster-building process, while not totally unique, has created one of the first successful state cluster programs in the nation. It took the effort of more than a thousand creators, and has evolved into an undertaking embracing more people and regions. Arizona makes no claim that its way is the right way for other regions. In fact, other clusters have borrowed from Arizona's concept and created their own version of what a cluster is and how best to implement it. A cluster is a process rather than a step-by-step plan that can be followed anywhere. But there is little doubt that the model is a good one. Arizona is confident that its plan has the right ingredients to significantly better the state's economy in the twenty-first century.

Robert (Bob) Breault is president of Breault Research Organization of Tucson, Arizona, and cochairman of the Arizona Optics Industry Association, 6400 East Grant Road, #350, Tucson, AZ 85715; e-mail: bbreault@breault.com. *The author acknowledges that he has drawn upon several internal Governor's Strategic Partnership for Economic Development (GSPED) documents whose authors are unknown and therefore cannot be cited individually. Among the documents that had authorial attribution were the following:*

1. Alan Korwin et al., Arizona's Economy is Everyone's Business, *GSPED, March 1992.*

2. Doug Henton, John Melville and Kim Walesh, Building Economic Communities: How Civic Entrepreneurs are Transforming America, *San Francisco: Jossey-Bass, February 1997.*

3. C. Hendry and J. Brown, City University Business School (UK), R. DeFilippi (Suffolk University), and R. Hassink, "Industry Clusters as Commercial, Knowledge, and Institutional Networks," in Interim Networks: Organization and Industrial Competitiveness *(ed. A. Grandovi), Routledge, 1999.*

4. D. Henton and K. Walesh, Reinventing Communities: Clusters and their Next Evolution, *International Society for Optical Engineering, 1996.*

Ultrasonics With Laser In-Coupling and Air Out-Coupling

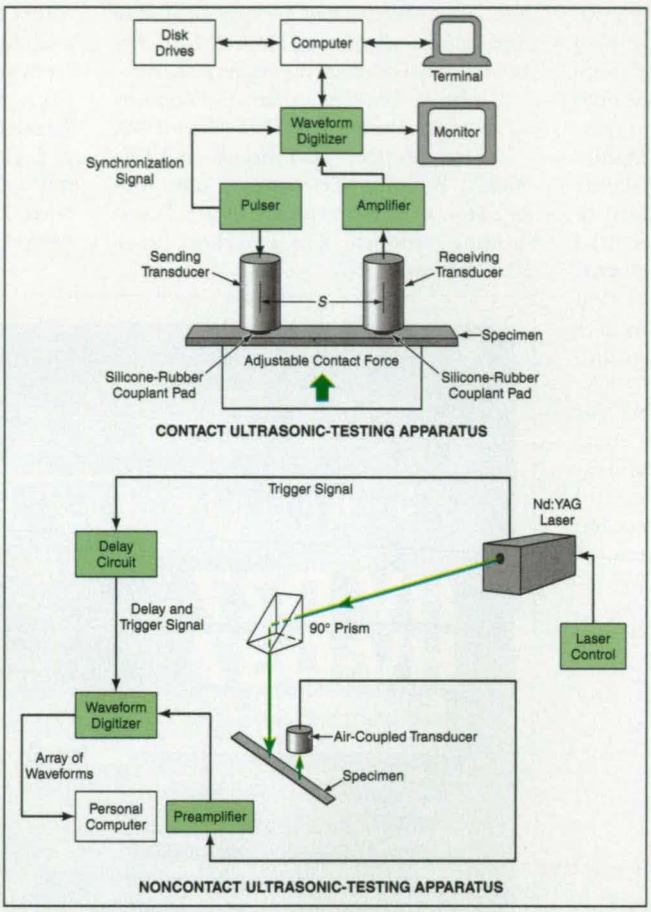
This method shows promise for noncontact, nondestructive characterization of materials and structures.

John H. Glenn Research Center, Cleveland, Ohio

Efforts are under way to develop a technique of noncontact acousto-ultrasonic testing in which (1) a pulsed laser beam excites ultrasonic waves in a plate specimen and (2) the ultrasonic waves are detected by use of one or more focusing air-coupled ultrasonic transducer(s) placed at a short distance away from the specimen and aimed at the spot(s) of interest on the specimen. This technique is intended to be an alternative to an older technique of contact acousto-ultrasonic testing; when fully developed, this noncontact technique could be used to characterize materials and monitor integrity of structures in locations that are inaccessible to contact ultrasonic probes or in situations in which contact ultrasonic probes cannot or should not be used.

The acousto-ultrasonic method has been shown to be useful for assessing mechanical properties of composite-material structures. Plate-wave analysis has been used to quantify moduli of elasticity of composite materials. Rates of decay of ultrasonic signals can be used to monitor residual strengths or crack densities. The present development is expected to extend these capabilities from the contact to the noncontact regime. It has been envisioned that a noncontact acousto-ultrasonic testing technique would be especially useful for monitoring changes in the properties of ceramic- and metal-matrix composite materials, and of aircraft-engine structural components made of these materials, during thermomechanical testing and during engine operation.

The use of a laser as a remote (and thus also noncontact) ultrasound-input source and as part of an ultrasound detector has been under investigation for a number of years. The use of a noncontact piezoelectric ultrasonic transducer coupled through an airgap has also been under study. Laboratory experience has led to the conclusion that a laser is more useful as an ultrasound-input device than as part of a detector, while an air-coupled piezoelectric transducer is more useful as a detector than as an ultrasound-input device. Taking advantage of this lesson of experience, the present laser-in-coupling/air-out-coupling technique combines the two named means of coupling in such a way as to obtain a signal-to-noise ratio greater than can be achieved in other noncontact ultrasonic techniques that involve laser or air coupling.



The **Noncontact Ultrasonic-Testing Apparatus** with laser in-coupling and output coupling via air reproduces the basic geometry of the contact apparatus.

The figure schematically depicts two acousto-ultrasonic testing apparatuses; one that implements an older contact technique and one that implements the present noncontact technique. In the noncontact apparatus, the beam from a pulsed neodymium:yttrium aluminum garnet (Nd:YAG) laser is aimed at a spot on the specimen; this is the same spot where, in the contact apparatus, the sending transducer would be coupled to the specimen via a dry (silicone rubber) couplant pad. The air-coupled transducer in the noncontact apparatus is positioned and oriented to be sensitive to the spot on the specimen where, in the contact apparatus, the receiving transducer would be coupled to the specimen via another silicone rubber pad. A nonfocusing micromachined capacitance transducer can be used as an alternative to the air-coupled piezoelectric transducer (and is characterized by a broader frequency response), provided that it can be placed close enough to the specimen.

In experiments, rates of decay of ultrasonic energy in SiC/SiC ceramic-matrix and SiC/Ti metal-matrix composite-material specimens were measured by the contact technique and by the present noncontact technique. For each noncontact measurement, the laser pulse energy was ≈13 mJ and the air-coupled acoustic transducer was one with a broad frequency response nominally centered at 0.25, 0.5, 1.0, or 2.0 MHz. The rates of decay of ultrasonic energy were found to be higher for the contact measurements; the difference has been attributed to loss of energy via the contacts, and this attribution, in turn, seems to imply that the noncontact rate of decay is a more nearly pure measure of attenuation of ultrasound within the specimen. Still, contact measurements have been successful in revealing mechanical fatigue in the specimen materials; it is important that this be so, inasmuch as in projected uses for monitoring the integrity of aircraft components, it will often be necessary to take measurements in the presence of support structures that cause loss of ultrasonic energy. In both the contact and noncontact techniques, rates of decay of ultrasonic signals have been observed to increase with frequency.

Several concerns must be addressed in further development efforts. One is potential destructiveness of the laser pulse. Another is attenuation of the ultrasonic signal in output coupling via air; this attenuation imposes a practical upper limit on the usable frequency range.

This work was done by Harold E. Kautz of **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16916.

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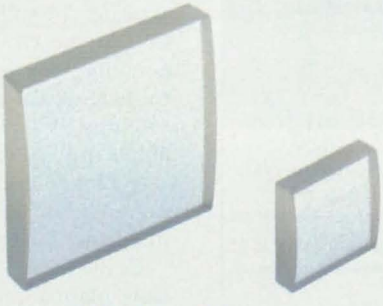

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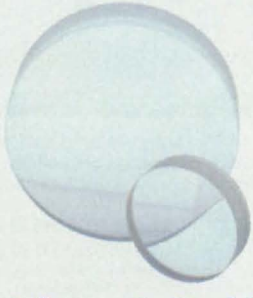

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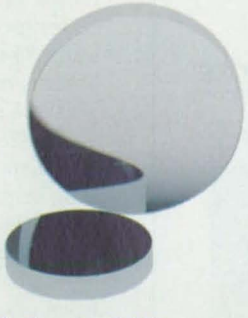

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Sulfur Lamp With $CaBr_2$ Additive for Enhanced Plant Growth

Addition of $CaBr_2$ intensifies red light, which is favored by plants.

John F. Kennedy Space Center, Florida

Calcium bromide can be added to the sulfur filling in a sulfur lamp to increase the emission of red light for enhanced growth of plants. Red light is more efficacious for plant growth than is visible light at shorter wavelengths. The addition of $CaBr_2$ increases the emission at wavelengths in the vicinity of 625 nm, where the quantum efficiency for photosynthesis is close to 1.

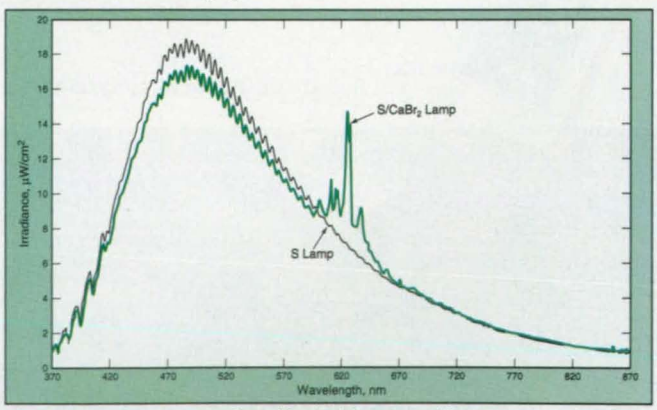
A sulfur lamp is an electrodeless lamp that includes an evacuated quartz bulb partly backfilled with argon and with a little sulfur, plus a source of microwave power for exciting a plasma within the bulb. A sulfur lamp is very efficient for visible lighting. An attempt to increase the emission of red light by increasing the sulfur content would result in an excessive reduction in the emission of blue light. Alternatively, following a common practice in the lighting industry, one could attempt to increase the red emission by adding such metal halides as sodium iodide: in the presence of the lamp plasma, the metal atoms in most such additives become excited and ionized and they radiate in the desired spectral region, but they also emit unwanted infrared line radiation, with a consequent reduction in efficacy for growth of plants.

Unlike other metal halide additives, in the presence of the lamp plasma, calcium bromide emits primarily molecular radiation at wavelengths in the vicinity of 625 nm, with minimal infrared emission. Thus, calcium bromide can be used to increase the emission of the desired red light. A representative experimental lamp based on this concept is made of a thin-wall, 35-mm-diameter quartz bulb containing tens of milligrams of sulfur, a few milligrams of $CaBr_2$, and argon at a pressure of about 50 torr (6.7 kPa). As shown in the figure, the $CaBr_2$ filling increases the desired red emission at the cost of only a small decrease in shorter-wavelength emission and with little or no increase in infrared emission.

This work was done by Youngzhang Leng and Donald A. MacLennan of Fusion Lighting, Inc., for **Kennedy Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to: Donald A. MacLennan, Fusion Lighting, 7524 Standish Place, Rockville, MD 20855; (301) 284-7200.

Refer to KSC-11970, volume and number of this NASA Tech Briefs *issue, and the page number.*



The **Measured Spectrum of a Sulfur/Calcium Bromide Lamp** is plotted along with the spectrum of a similar sulfur lamp without calcium bromide. The prominent spectral peak of the $S/CaBr_2$ lamp lies at the wavelength region of highest quantum efficiency for photosynthesis in plants.

Nonsaturating Electronic Image Sensors

In each pixel, charge would be integrated as long as necessary, but not longer.

NASA's Jet Propulsion Laboratory, Pasadena, California

Focal-plane electronic image sensors that would not saturate when exposed to intense illumination have been proposed. These sensors could be used to acquire accurate, scientific-quality data on images (including spectral images), even when the images contain both very bright and very dark areas. The proposed sensors would not contain automatic gain-control (AGC) circuitry, yet their dynamic ranges would exceed those of sensors with AGC. Unlike AGC circuitry, the circuitry of the proposed sensors would not change noise levels and would not compress image data.

The proposed sensors would be of the active-pixel-sensor (APS) type. The designs of these sensors would exploit the possibility of making APS circuitry operate on each pixel individually during acquisition of image data. In particular, the amount of photocharge accumulated in each pixel during each exposure would be monitored, and the pixel would be either reset or turned off when the charge increased beyond a preset threshold.

In one suggested implementation, a comparator and a counter would be added to the readout circuit of each pixel. When the amount of charge reached the preset threshold during an exposure, the pixel would be reset and the count incremented by one. At the end of the exposure, the total readout signal charge for each pixel would be the sum of (1) the number of resets × the threshold charge plus (2) the charge accumulated since the last reset. In the presence of bright light, the repeated resets would prevent saturation. In the presence of dim light, the photocharge would be allowed to grow for as long a time as necessary during an exposure.

In another suggested implementation, the readout circuitry for each pixel would include a sample-and-hold circuit. In this case, the pixel value would be captured whenever the sampled photocharge exceeded a preset threshold and the integration time counted separately. In either implementation, it may be possible to obtain satisfactory performance while using an analog-to-digital converter of fewer bits than would ordinarily be needed for a given dynamic range.

This work was done by Gregory Bearman, Bedabrata Pain, and Robert Stirbl of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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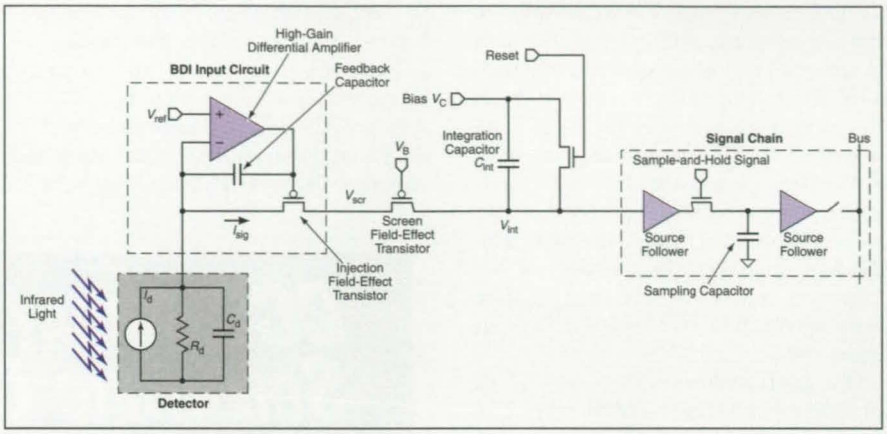
Refer to NPO-20560, volume and number of this NASA Tech Briefs *issue, and the page number.*

Readout for Fast IR Imaging With Large Detector Capacitance

Improvements are effected by taking account of response times in designing readout amplifiers.

NASA's Jet Propulsion Laboratory, Pasadena, California



The **Stages Following the BDI Input Circuit** are optimized, pursuant to equations for response times, to minimize image lag and other errors.

A methodology for designing highly accurate readout circuits for infrared (IR) image detectors that have large pixel detector capacitances (of the order of tens of picofarads) and are required to operate with short exposure times (<100 μs) has been devised. In this context, "highly accurate" signifies capable of (1) nearly linear response over a wide dynamic range with (2) little or no image lag ("ghost" image readout attributable to capacitive retention of charge from preceding image frames), and (3) low readout noise. The methodology has been used to enhance the performance of NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), and is expected to satisfy an increasing need for highly accurate readout circuits in other applications, including other imaging spectrometers and infrared video cameras now undergoing development.

The methodology improves upon the prior art in two main ways:

- It provides for refinement of the design of pixel amplifiers and other pixel readout circuitry on the basis of understanding gained through analysis of previously neglected second-order electronic effects — including notably image lag related to abrupt transitions of signal currents.
- It incorporates the concept that, at least in principle, it should be possible to derive an algorithm to correct for image lag.

The readout circuitry for each pixel, as contemplated in this methodology, is based on that of the AVIRIS. This circuitry (see figure) features a conventional buffered-direct-injection (BDI) input circuit followed by amplifier stages of optimized design. Similar BDI readout circuits designed according to older methodology generate residual image signals when bright images are followed by dark images, giving rise to errors in the estimates of the dark images; and when dark images are followed by bright images, responses are oscillatory, giving rise to errors in estimates of the bright images. The errors are functions of time and detector capacitances.

The analysis of second-order effects yields closed-form expressions for response times for both low-to-high and high-to-low transitions. These expressions are what make it possible to optimize pixel amplifier design and to choose appropriate feedback capacitors to minimize circuit error and image lag. In an initial application of this part of the methodology to a linear array of photodetectors for the AVIRIS, it was found that the signal-to-noise ratio was increased by a factor of 2 to 3, relative to older designs, and that image lag was reduced to less than 10 percent over the entire dynamic range of pixel signal current from 10 pA to 10 nA. The measured input-referred noise was found to be less than 300 electrons.

A first-order analysis has been performed in an initial effort to develop software to compensate for image lag. This analysis yields recursive equations that can be used to estimate and correct for errors. Software that implements these equations has been tested on AVIRIS readout data and found to reduce errors but also to occasionally introduce new errors. The inability to

eliminate all errors has been attributed to inadequate mathematical modeling of circuit behavior, including inaccuracies in estimates of response times. To achieve greater accuracy, it would be necessary to derive equations of greater complexity, based on a second-order analysis. Of course, it would be more difficult to implement such equations in software.

This work was done by Bedabrata Pain of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category. NPO-20522*

Maskless Gray-Scale X-Ray Lithography

Spatial variations in exposure of photoresist would be effected through variations in scan rates.

NASA's Jet Propulsion Laboratory, Pasadena, California

In a proposed technique of maskless gray-scale x-ray lithography, a photoresist to be patterned would be exposed to a parallel beam of hard x-rays. As explained below, the photoresist would be translated across the beam at a varying rate to effect one-dimensional spatial variations in the radiation dose received by the photoresist. The technique would be particularly suitable for making diffraction gratings and similar items.

In gray-scale lithography in general, the radiation dose to a photoresist on a substrate is made to vary spatially, within a range in which the solubility of the exposed photoresist in a developer liquid varies with the dose. In customary gray-scale x-ray lithography, the required spatial variation in the dose is achieved by use of a mask. The mask and the photoresist-covered substrate are translated as a unit across an x-ray beam at a constant rate to obtain the required integrated dose to the mask.

The lithographically desirable characteristics of a parallel beam of hard x-rays include a large depth of field (typically characterized by image dispersion less than 1 μm over a depth of 15 mm) and negligible reflections from photoresist defects and surfaces. A parallel beam of hard x-rays (wavelengths < 10 Å) for use in the proposed technique could be generated by a synchrotron source in conjunction with a slit filter (typically 50 nm wide).

In the proposed technique, the photoresist would not be masked. The gradients in the radiation dose needed to obtain gradients in the density of the developed photoresist would be generated by controlled variations in the rate of translation of the x-ray beam across the photoresist. These controlled variations would suffice to define the desired features (variations of the height of the subsequently developed photoresist) to within submicron dimensions, within the 15-mm depth of field.

After exposure to x-rays, the photoresist would be developed in the customary manner. After development, the photoresist would be dried, giving rise to spatial consolidation of the photoresist into thickness gradients corresponding to the density gradients. The dosage gradients could be chosen to achieve desired final thickness gradients; for example, to produce triangular- or sawtooth-cross-section blazes for diffraction gratings. The large depth of field could be exploited to form such blazes on curved surfaces.

This work was done by Frank Hartley of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category. NPO-20445*

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OptoBrite Devices, Woodinville, WA, introduces the 903 product line, a 9-mm mounted laser diode-based fiber-pigtailed package with >80 percent coupling. The company says that the device has a brightness four times that of the typical 0.22-numerical-aperture unit with the optionally available 0.11-numerical-aperture fiber. OptoBrite suggest such applications as medical devices, night vision, printing, and pumping of other solid-state lasers. The 903 package is available in a variety of wavelengths from 635 to 1064 nm and power levels up to 1000 mW.

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Digital IR Thermal Imager

Raytheon Co., Dallas, TX, is offering the ControlIR 2000, a digital IR heat vision thermal imager, intended for original equipment manufacturers and system integrators targeting security, process control, and machine vision applications. Compared to analog technology, Raytheon says, the new IR camera digitizes images at 12 bits rather than 10, improving its dynamic temperature range by a factor of four. The company says the ControlIR 2000 also has twice the sensitivity, or noise equivalent temperature difference (NETD), and twice the nonuniformity.

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UV Industrial-Grade DPSS

Lambda Physik, Ft. Lauderdale, FL, designed its new Gator™ 355-3 industrial-grade UV diode-pumped solid-state laser for micromachining and microdrilling hard materials. With a 10-kHz repetition rate and more than 3 W average power, the Gator 355-3 has a hermetically sealed laser head and comes with a 5000-hour diode lifetime warranty. The company says the complete hands-free operation and remote/removable supply unit are key industrial design elements. Lambda Physik recommends the laser for high-aspect-ratio microdrilling in many hard materials.

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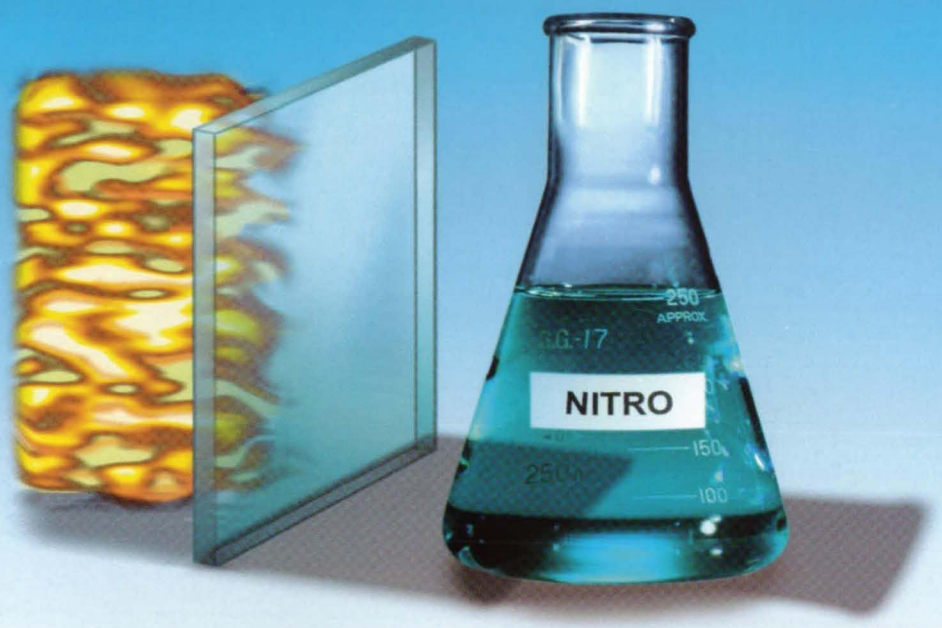

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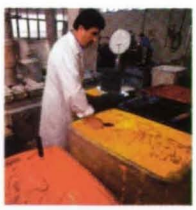

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801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820
821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840

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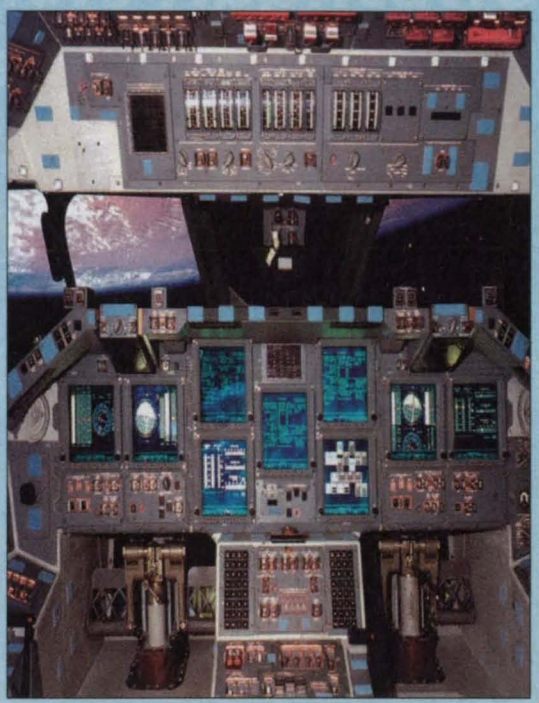
FREE NEWSLETTER

New Cockpit Technology Modernizes Shuttles

Multifunction Electronic Display Subsystem (MEDS)
Honeywell Space Systems
Phoenix, AZ
(602) 822-3746
www.honeywell.com

The Space Shuttle Atlantis recently made its first flight with Honeywell's "glass cockpit" Multifunction Electronic Display Subsystem (MEDS), which helped astronauts navigate and land the orbiter. MEDS replaces the orbiter's electromechanical and cathode ray tube (CRT) displays, which were designed in the 1970s. Equipped with the first glass cockpit ever to fly in space, Atlantis was suited with nine MEDS displays in the forward flight deck and two MEDS units in the aft flight deck.

"Our MEDS technology, with its genesis in Honeywell's display system for the Boeing 777 aircraft, will provide NASA's fleet of orbiters with the most advanced commercial and military flat-panel display technology available today," said Jay Lovelace, Vice President and Location Manager for Honeywell Space Systems.



Using MEDS, shuttle crews have easy access to vital information through the two- and three-dimensional color graphic and video capabilities. By reading the displays, astronauts see information including speed, altitude, position, and direction. Information also is interchangeable between screens, allowing crews to select the display format that best suits the needs of their particular mission.

MEDS eliminates obsolescence concerns and is less expensive to maintain than present electromechanical devices. In addition to reducing maintenance costs, MEDS will reduce vehicle weight and power consumption, freeing more power for longer flights; improve shuttle reliability and performance; and improve shuttle safety by simplifying cockpit panels. MEDS also is capable of future upgrades. Honeywell will provide a new glass cockpit for all four shuttle orbiters.

For More Information Circle No. 750

NASA's LANDSAT 7 Receives Innovative Processing System

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Plymouth, MN
(800) 727-4669
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Landsat 7, an imaging satellite managed cooperatively by NASA, the National Oceanic and Atmospheric Administration (NOAA), and the United States Geological Survey (USGS), was launched in the summer of 1998. As a component of the Mission to Planet Earth (MTPE) program, it began collecting and transmitting global and seasonal land images for scientific and commercial purposes. On the receiving end of the satellite transmissions was an antenna at the USGS's Earth Resource Observation Systems (EROS) Data Center located in Sioux Falls, SD. There, the incoming data was recorded and processed to produce high-resolution images of the earth's surface.

These processes were performed by the Landsat 7 Processing Unit's (LPS) powerful computing system. Like the satellite itself, the LPS was designed from the ground up and had to meet some demanding criteria for capturing and processing the satellite's raw data transmissions.

The data from the satellite is encoded with various types of error-correcting coding algorithms. The LPS consists of five SGI Challenge XL computers, each outfitted with two Ciprico 34-Gb disk arrays. Embedded within each string are two channels for different bands or types of data, each being transmitted at a sustained rate of 75 Mbps to one of the XLs. The data from each channel is captured to one of the XL's two Ciprico disk arrays.

The LPS "unpacks" the data, frame-synchronizes it, and removes the additional coding information. The processed data is then transferred to the other Ciprico array on each Challenge. It is held there until it can be transferred to a tape archive that is part of a much bigger system — the Earth Observing System Data Information System (EOSDIS) Distributed Active Archive Center (DAAC). This data is then accessible to the scientific community.

For More Information Circle No. 751

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DEWE-RACK-16 and any PC

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For More Information Circle No. 534

Analysis Enhanced Test: Combining Data Acquisition and Analysis

No one needs to tell engineers today that their jobs are getting tougher. Complex projects, time constraints, financial limitations, warranty issues, and the constant pressure to innovate continue to push the limits of engineering ability. From automotive and aerospace design, to semiconductors and advanced communications systems, the basic challenges are essentially the same: design the best possible products at the lowest possible cost — and get them to market faster than the competition. Faced with this difficult task, it's no wonder that engineers are looking for new tools to make their jobs easier and to streamline the steps required to go from concept to production.

Integrating phases of the engineering process would be beneficial to the engineer. If software tools were available that supported multiple phases of the engineering process, valuable time and money could be saved. In addition, this would allow engineers to adopt a standard tool set for design development so that individuals would not need to learn and use multiple software packages, and could easily share work with their colleagues. New tools are now available that do just this and are helping to reduce some of the pressures felt by engineers today.

Process Integration

The challenges faced by research and design engineers are often tackled through multi-phased, iterative processes. Frequently, these processes require several steps, including:

- **Data acquisition and test:** The development of a test system for the purpose of taking measurements and collecting data from a real-world component or system. Testing incorporates data acquisition, low-level analysis, and data storage.
- **Data analysis and visualization:** Once the data is collected, it is often stored in a database for post-processing. This involves applying rigorous analysis methods, such as signal processing, wavelets, and statistical analysis to gain an understanding of the system under test. This is frequently an iterative task during which the design is refined.
- **Verification:** Verification is an important follow-on task in design development. It involves confirming that the final part or system works as expected without failure. This portion of the engineering process is highly rigorous.
- **Reporting:** When finalizing a project or specific test, a report often is written to document the process and share the results.

Though the end result (such as a report, a component, or a system) varies for each individual engineering challenge, the steps involved in all areas of design and development need to be tightly integrated. This is because it is often the case that several iterations of the process are run through before accurate or useful results are obtained.

One of the biggest challenges in the process is to gain insight and understanding about the behavior of a physical part or system. This discovery phase can involve taking measurements from a physical component in order to model or analyze its behavior during the early development stages (prototyping), or testing a component or system to determine if it is performing as expected (design verification). The development of a measurement system often is undertaken by the engineer to measure physical parameters about the device and to perform in-depth analysis and visualization on the information obtained. In other words, a measurement system integrates the data acquisition and test phase with the data analysis and visualization phase. Furthermore, since verification involves applying rigorous test and analysis procedures to the design, benefit also can be realized in the verification phase due to this integration.

There are, therefore, two key components to a measurement system: data acquisition, and powerful analysis and visualization functionality. Because the purpose of data acquisition is often, in the end, to gain greater insight into the component or system being studied, advanced analysis and visualization play a key role in the design process. Tools such as signal processing, statistical analysis, or even neural networks are employed to model or explore the data in detail and refine design parameters.

Analysis Enhanced Test: Integrating Data Acquisition and Analysis

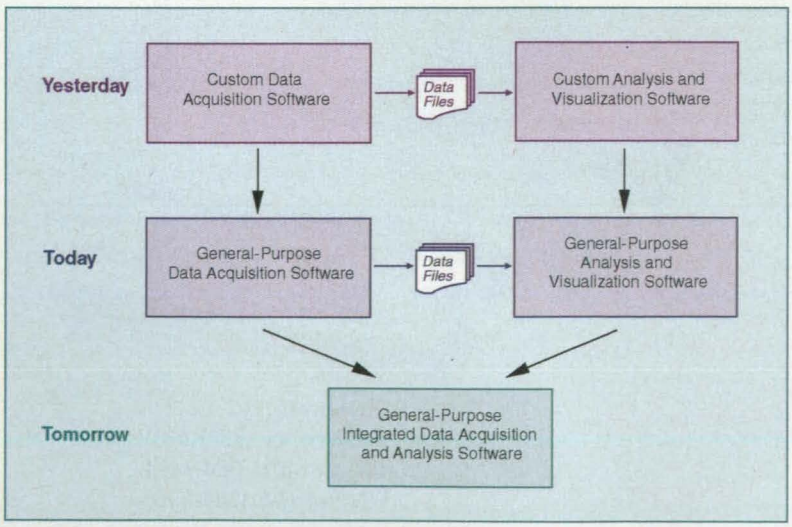

Figure 1: Data acquisition and analysis historically have been separate tasks that each required specialized software-collected data to be saved to file and transferred from one environment to the other. Analysis-enhanced test integrates data acquisition and analysis in a single software environment.

This type of high-level analysis requires specialized math and analysis methods that are not available in standalone data acquisition packages.

The Evolution of Analysis Enhanced Test

Analysis enhanced test is a new approach for test and measurement applications. Analysis enhanced test refers to the integration of the data acquisition and test phase with the analysis and visualization task. The creation of a measurement system — an integrated data acquisition and analysis environment — can greatly benefit an engineer and ultimately save time and money.

It's important to take a look at the history of test and analysis, as well as what's currently being done in order to get a true understanding of the benefits of an integrated system. Historically, data acquisition has been a task done in a lab. A test setup was developed, and frequently a technician ran the test and collected the data. This data was then given to an engineer to analyze. The design might be modified in some way, depending on the results of the analysis, and the test would be run again. These steps would be repeated until the design was finalized.

Until just a few years ago, the data acquisition and analysis applications were created with custom C-code. Often, the user would need to write low-level drivers to communicate with the data acquisition hardware, and then save the captured data to file for post-processing. A custom C or Fortran program also was written to read the captured data from the file, and produce the appropriate plots or calculation results. All this took a considerable amount of time and effort, and required writing large amounts of custom code. And every time a new hardware device was used or a different calculation was performed on the data, the code had to be modified by hand to accommodate the change. In hindsight, all of this seems extremely complex. However, at the time, these were merely considered part of the job.

Today, time and budget constraints have pushed engineers into the lab to do more of their own testing. Tools have been created that help simplify the design tasks. Specialized general-purpose software packages are available for separately handling the acquisition and analysis tasks. Developed within the last 10 to 15 years, these general-purpose programs represent the current generation for simplifying the engineering process. Software packages are available to create the data acquisition system or to apply advanced analysis and visualization techniques without writing code.

What Engineers Are Doing

The data acquisition and analysis sections of a test system are still largely separated. Data acquisition is accomplished in a lab with a "canned" test set-up configuration. The large data sets gathered from the test are stored to disk or to databases, and then brought back to the engineering office for off-line analysis. These steps are continued through several iterations until the design is completed. This way of working can require several different software packages: one for data acquisition (usually a proprietary package provided by the DAQ hardware vendor), one for storing the data (often a database), and another for analyzing and visualizing the data.

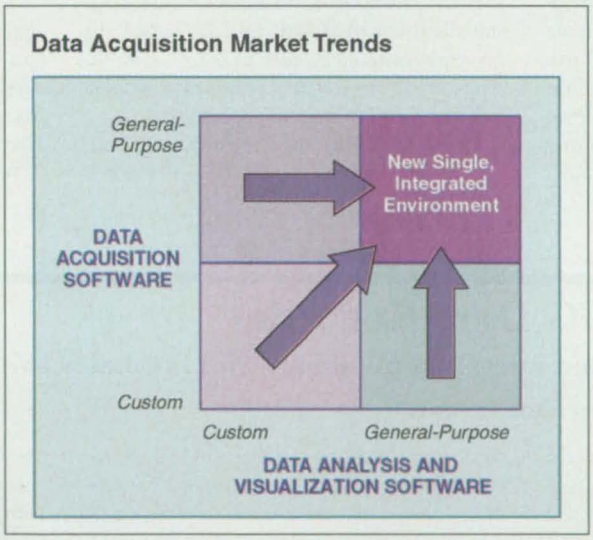

Figure 2: New general-purpose tools that support both aspects of the engineering process are helping to integrate these formerly separate tasks.

Engineers utilize these tools in combination to get their job done, and in the push to get products to market faster, have devised methods to integrate them. They often mix and match different software packages or combine them with custom C or Fortran code for specific portions of the task. But as anyone who has had to create such a system knows, the acquisition and analysis task is still far from easy, and much time is spent in creating customized, integrated solutions. Engineers choose an approach, knowing that if the data acquisition side is the focus of the solution, the analysis tools are likely to be sub-optimal and vice-versa.

For best results, data acquisition and analysis can no longer be separate tasks. They must be tightly tied, not only to meet time constraints, but also to ensure that the product will work exactly as designed. An integrated data acquisition and analysis system allows engineers to test out new algorithms, experiment with different components, make decisions on the fly, and instantly verify the component model using real-world measurements.

Historically, analysis and visualization software such as MATLAB (from The MathWorks) has been used extensively by test and measurement professionals to post-process the massive amounts of data collected. The need to close the gap between analysis and test necessitated the development for test systems based on MATLAB. Often, engineers and scientists would develop custom test set-ups that allowed them to go directly from hardware to MATLAB in order to simplify their design and development process. Coupling products like MATLAB with data acquisition systems allows engineers and scientists to do things that were not possible before.

Analysis enhanced test is a growing trend for technical professionals. It ties together the various phases of the development process in order to get better results, faster. In the past, engineers and scientists forged their own way, developing custom software environments that would allow them to combine data acquisition and analysis. Today, however, new tools are available to support this way of working and provide a way to get up and running — and done — faster than ever before.

For more information, contact the author, Jane Price, Data Acquisition Marketing Manager, at The MathWorks, 3 Apple Hill Dr., Natick, MA 01760; Tel: 508-647-7000; Fax: 508-647-7016; or visit www.mathworks.com

Data-Filter Algorithm for Monitoring a Power System

In the manner of human experts, redundancy is utilized to detect anomalies.

Lyndon B. Johnson Space Center, Houston, Texas

An algorithm has been developed for a computer-based electronic system that would aid human ground controllers in monitoring data from sensors in the electric-power system of the International Space Station. Among other things, the algorithm encodes knowledge of human experts; thereby harnessing the ability of computers to do diagnostic calculations that human experts would do but that take much longer when done manually. The algorithm also has potential for application to a variety of systems outside the aerospace industry.

The Space Station power system is characterized by two levels of redundancy: (1) two or more sensors measure the same value; and (2) synthetic (probable) measurements can be generated by taking account of physical laws that govern the monitored power system. Traditionally, ground controllers utilize the second level of redundancy in that they compare any suspicious sensor measurements against probable measurements, which, heretofore, they have calculated by hand.

Although NASA has employed autonomous electrical power systems for several years, computers have not been used to help ground controllers diagnose anomalies in sensor measurements. Control-center consoles have merely alerted controllers when sensor readings have exceeded set maximum or fallen below set minimum values.

The present algorithm systematically filters possibly conflicting and erroneous sensor data to determine the most probable values of critical measurements. The algorithm generates the most probable values of current and voltage for the sensors in question, draws conclusions from statistical information, and indicates, to ground controllers, one of three possible types of causes for any anomalies: sensor failures, soft faults, and sensor drift.

The algorithm, implemented in a C++ computer program, calculates the most probable values from all available measurements, real and calculated. If a value does not fall within the 3-standard-deviation (3σ) range for all measurements, the measurement that differs most from the estimated value is eliminated from the calculation. This procedure is repeated until either the estimate falls within the 3σ range for the remaining measurements or only two disagreeing measurements are left, in which case the value is considered indeterminate. The most probable values of sensor measurements are calculated from the means and variances of redundant values, creating a weighted average based on the variance of each sensor.

This work was done by Wallace Kelly III of Rockwell Space Operations Company for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
MSC-22728

Portable ECG/EGG Data Recorder

This is a noninvasive unit that interferes minimally with normal activities.

Lyndon B. Johnson Space Center, Houston, Texas

A portable electronic unit with no moving parts except button switches digitizes and stores a 48-hour record of the myoelectric activity of the stomach and heart as sensed via electrodes on the surface of the abdomen. Just as the more familiar electrocardiogram (ECG) is useful in diagnosing the condition of the heart, the digital electrogastrogram (EGG) that is also obtained by this portable data recorder is useful in assessing changes in gastric function.

This unit, called the "BioLog," was originally designed to aid studies of gastric changes and related changes in the activity of the autonomic nervous system associated with space motion sickness in astronauts. However the unit can also be used on Earth to collect the same or other types of physiological data from patients who object to the restrictions imposed by traditional stationary physiological monitoring equipment. The unit has a volume of $< 1{,}000\ cm^3$ and a mass of 0.68 kg. It can be mounted on the wearer's belt or attached to the wearer's clothing by use of hook-and-pile fastening material and a custom-designed pocket.

The unit is connected to high-input-impedance, low-output-impedance amplifiers that, in turn, are connected directly (via snap-on fasteners) to the electrodes on the patient's abdomen. This arrangement provides sufficient amplification at the signal source and sufficient immunity to extraneous electrical noise that the signal-to-noise ratio is great enough for ambulatory recording, unlike in older EGG recorders in which ambulatory recording was rendered useless by motion-induced artifacts in the signal.

The EGG can be discerned as a shift in the baseline of the ECG because the characteristic frequencies of the ECG (typically > 1 Hz) are significantly greater than those of the EGG (typically ≈ 0.05 Hz). The unit digitizes and records the ECG/EGG at a sampling rate of 10 Hz. When the recorded data are subsequently analyzed, they are filtered to separate them into EGG and ECG components.

The unit includes a clock that generates time tags for the data. A 9-V alkaline battery supplies the main operating power. When the main power is off, a capacitor of about 1 farad supplies backup power to keep the clock running for 29 days. A 16-character liquid-crystal device (LCD) displays the current time (in days, hours, and minutes) or other information as needed.

The data-storage medium is a static random-access memory (SRAM) circuit card. The SRAM is structured to enable the

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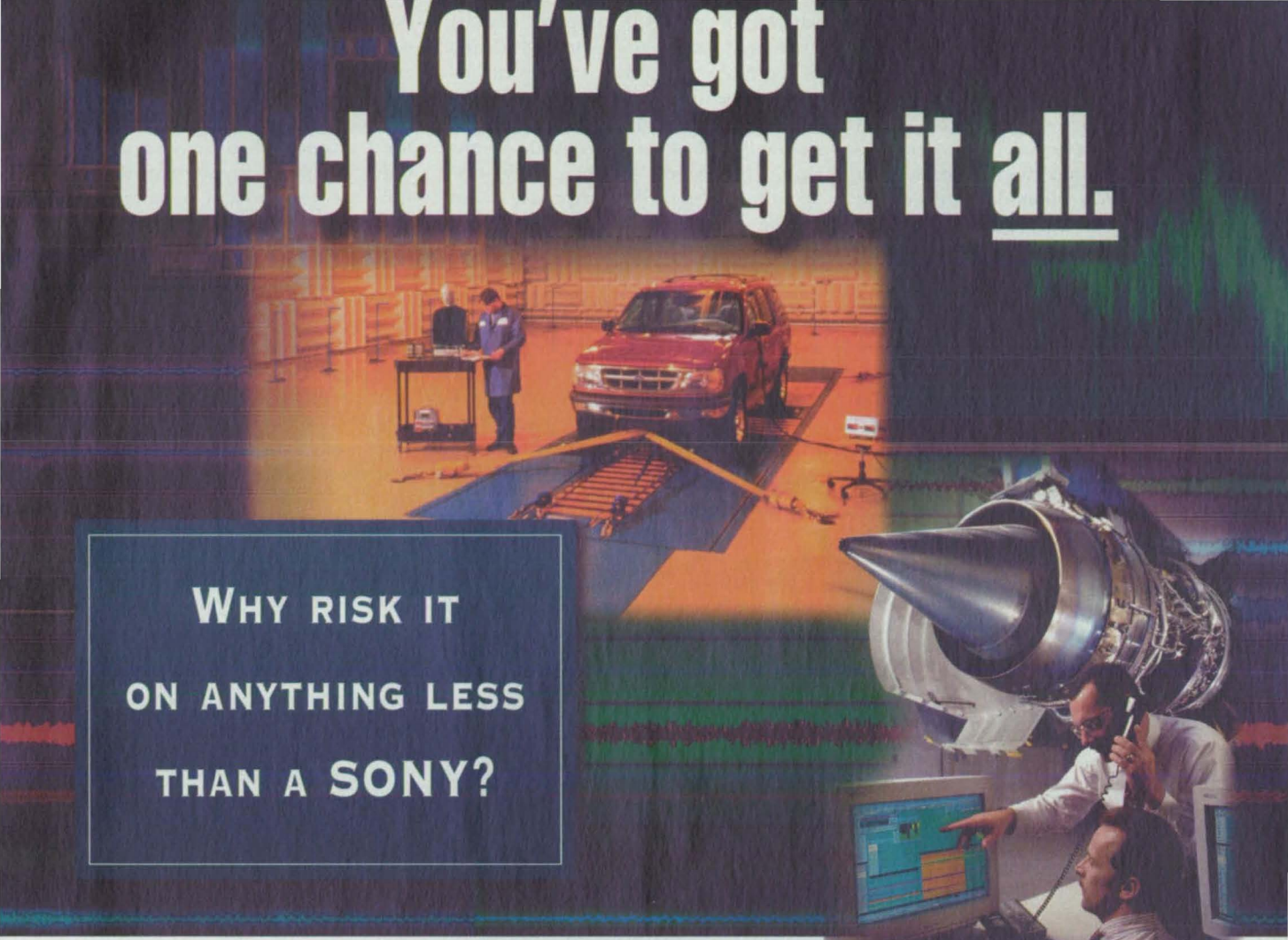

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For More Information Circle No. 527

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recording, within the single data channel, of event markers and other ancillary information time-locked to the ECG/EGG data. The recording of ancillary data involves the insertion of alternate data structures in the data stream. Two types of activity and the associated alternate data structures are accommodated; those that involve suspension of data logging and those for which the data recorded before and after are contiguous in time.

Activities that involve suspension of data logging include turning power on or off, resetting the clock, resetting recording to the beginning of the SRAM (this erases all data recorded previously), and calculation of system resources (battery power and the remaining unused portion of the SRAM). Activities that do not involve suspension of logging include the insertion of event markers by pressing of button switches on the outside of the unit. Five button switches and corresponding event markers are available and can be defined as the user sees fit, without modification of hardware or software. An alternate data structure identifies which event-marker button has been pressed and causes the report of the event to be time-locked to the data that follow. At the moment when an alternate data structure is inserted, the ECG/EGG data are stored in a buffer so that no discontinuity in the data occurs. To prevent activation by accidental contact, an event marker is not inserted until the corresponding button switch has been pressed for 1 second. When the data are subsequently analyzed, the alternate data structures are removed and, in cases of no interruption in logging, the data from before and after are concatenated.

An error code is displayed on the LCD to alert the user to problems with the operation of the unit. There are four error codes; the first indicates that the battery charge is too low, the second indicates that the SRAM card is inserted improperly, the third states the SRAM card is write-protected, and the fourth indicates that the SRAM was not properly initialized. The occurrence of any of these conditions prevents operation.

This work was done by Deborah L. Harm of **Johnson Space Center**, *Gwenn R. Sandoz and Charlene R. Jacobsen of KRUG Life Sciences, and Harve M. Hanish and Marty Loughry of UFI, Moro Bay, CA. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

KRUG Life Sciences, Inc.
1290 Hercules, Suite 120
Houston, TX 77058

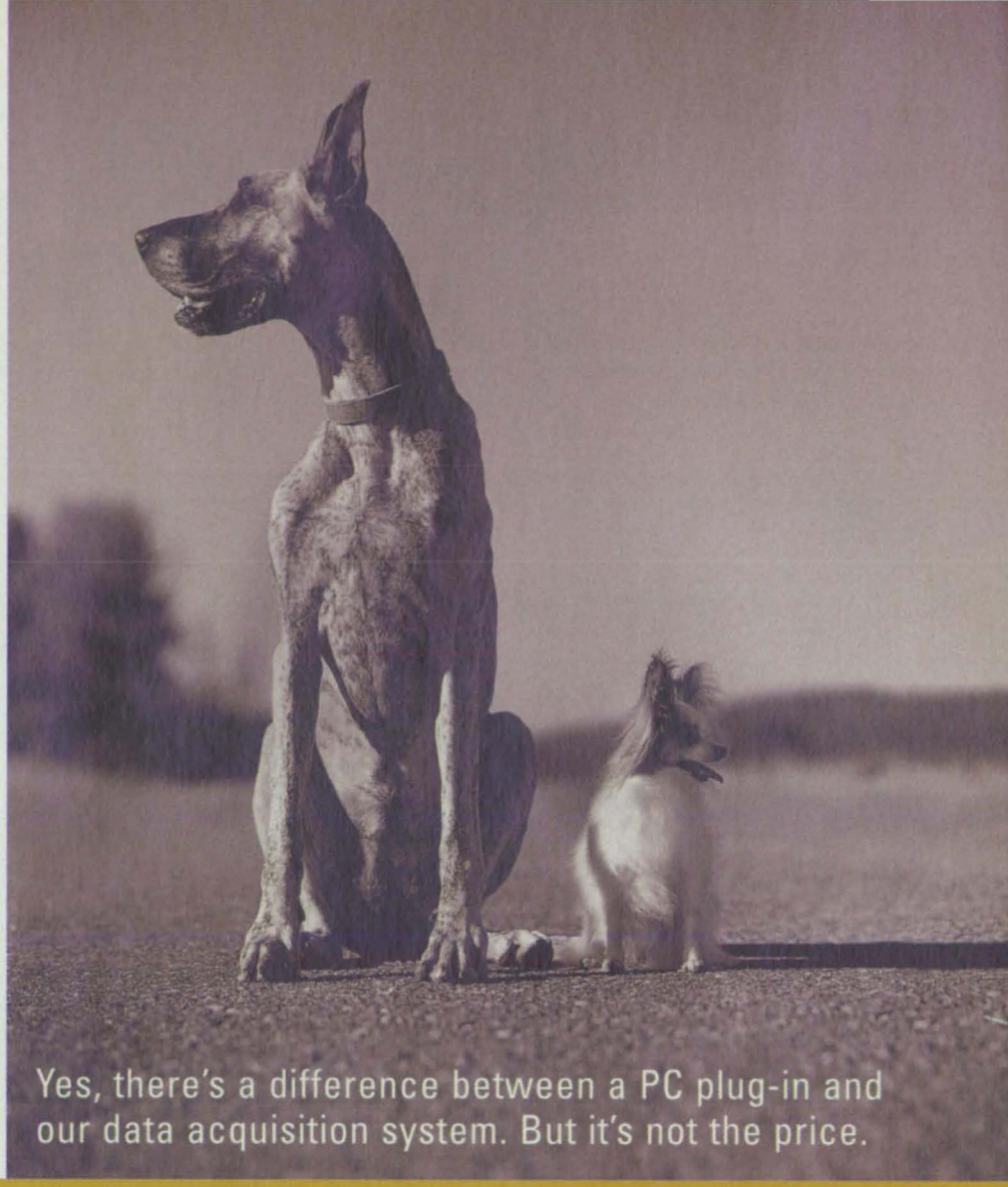
Refer to MSC-22677, volume and number of this NASA Tech Briefs *issue, and the page number.*

Software Facilitates Access to a Scientific Data Base

This program supports cooperative international scientific efforts.

Goddard Space Flight Center, Greenbelt, Maryland

The Coordinated Data Analysis Workshop Web (CDAWeb) is a web-based service that facilitates access to a scientific data base of the International Solar-Terrestrial Physics (ISTP) program and other programs that generate public scientific information. In this data base, physical-science parameters from diverse international sources are stored in the Common Data Format (CDF) standard developed by the National Space Science Data Center (NSSDC).



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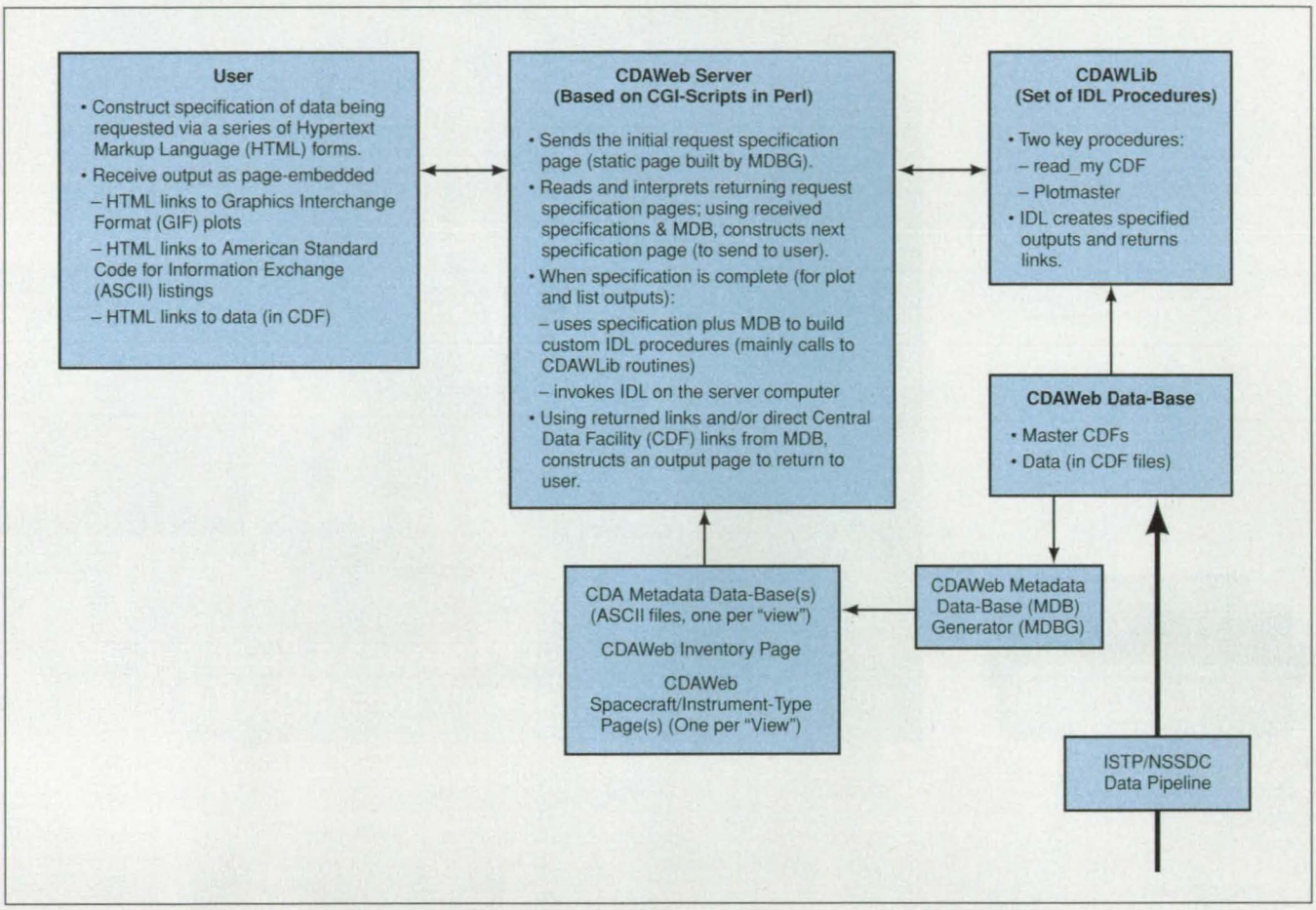
The data of the ISTP program and the CDAWeb service are parts of NASA's contribution to the Solar-Terrestrial Science Initiative of the Inter-Agency Consultative Group (IACG), a multinational space-science coordinating group. Under the auspices of IACG, CDAWeb mirror sites have been established at the Equator-S science center at the Max-Planck Institute in Garching, Germany, and at the Rutherford Appleton Laboratory in the United Kingdom.

CDAWeb is built using standard software packages. The "engine" of CDAWeb is a set of scripts in the Interactive Data Language (IDL) of Research Systems Inc. (RSI). CDAWeb also includes webpage software components and common gateway interface (CGI) scripts that act as interfaces between the IDL scripts and the user, plus supporting software utilities to create the metadata data-base files used by the interface scripts. The CDAWeb software package for mirror sites does not include IDL, which is a commercial product that must be obtained separately.

This work was done under the direction of Robert E. McGuire of **Goddard Space Flight Center**. *For further information, access the CDAWeb service at http://cdaweb.gsfc.nasa.gov or the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
GSC-14292



CDAWeb Assists the User in obtaining scientific data that have been stored in a prescribed format.

A Standard for Scientific Data Files

This standard and the software that implements it facilitate collaboration among scientists.

Marshall Space Flight Center, Alabama

The term "Instrument Data File Set" (IDFS) denotes both software and an underlying concept of a prescribed format for files of scientific data and metadata. The IDFS was developed to satisfy a need, in the space science community, to maintain data and metadata in a format that promotes efficient use of the information and that facilitates access to the information, thereby enhancing the ability of scientists to engage in collaborative research. Within the space science community, the IDFS has become a standard by default.

Metadata, which accompany scientific measurement data, can include information about formats of measurement data, parameters of scientific instruments, calibration tables, tables for conversion of measurement data to scientific units of measurement, timing factors, and other information that does not necessarily originate from scientific instruments but is necessary for research. The IDFS software provides easy access to IDFS-formatted data via a catalog subsystem and data access routines. The catalog subsystem contains information about which IDFS-formatted data are available for use. The data access routines extract IDFS-formatted data in a variety of ways for meaningful presentation.

The IDFS concept and software addresses the deficiencies of other methods for the storage and representation of space science data. Two key tasks that can be performed with the help of the IDFS

software are the conversion of telemetry values to engineering and scientific units and the registration of each datum with a given point in time; in this respect, the IDFS enables efficient presentation of the data from simultaneous measurements made on different instruments.

This work was done by Carrie Gonzalez, Joey Mukherjee, and Sandee Jeffers of Southwest Research Institute for **Marshall Space Flight Center**. *For more information, contact the Southwest Research Institute at (210) 522-2010.*
MFS-31325

Software for Display and Analysis of Scientific Data

Data can be obtained from globally distributed archives, then displayed and analyzed quickly.

Marshall Space Flight Center, Alabama

The Southwest Data Display and Analysis System (SDDAS) is a flexible, extensible software system intended to support analysis of space physics data from multiple instruments and multiple spacecraft missions. SDDAS was developed in response to the need of space scientists to be able to gain access to data and to display data, without concern about data management details, so that they can focus their efforts on scientific research.

SDDAS gives the scientists a software "toolbox" that can bridge the gap between data and scientific insight. SDDAS makes it possible to quickly display and analyze data in distributed archives from many different satellites and other sources by use of a diverse set of graphical application programs. Data can be ordered and delivered over the Internet, independently of the locations of archives and of the nature of the archival storage.

The graphical software tools are the heart of SDDAS and are oriented toward the examination of data in the Instrument Data File Set (IDFS) format, which is the subject of the preceding article. The development of SDDAS has been "bottom-up" rather than "top-down" and user-driven rather than organization-driven. SDDAS is adaptable to advances in computer technology; that is, it was designed to evolve in order to take advantage of new technology and changing users' requirements.

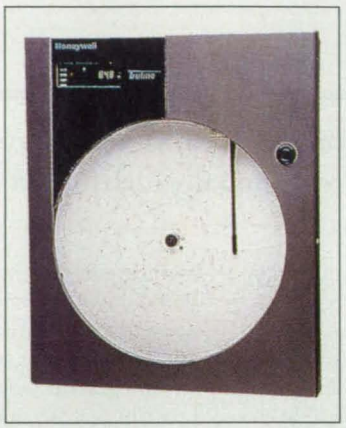
By using SDDAS, scientists can do a great deal of science without developing new software. The only preparation necessary for using SDDAS display and analyze data is to store the data in the IDFS format. In addition to enabling space scientists to focus more readily on research, SDDAS facilitates collaborative research through its flexibility, its emphasis on interactive analysis, and its capability for providing immediate access to data in globally distributed archives.

This work was done by Carrie Gonzalez, Joey Mukherjee, and Sandee Jeffers of Southwest Research Institute for **Marshall Space Flight Center**. *For more information, contact the Southwestern Research Institute at (210) 522-2010.*
MFS-31327

Dewetron, Charlestown, RI, offers the DEWE-3010-AC and DEWE-3010-DC **portable data recorders** that feature 8 slots for plug-in DEWE-MODULES that range from 1 to 8 channels each and adapt the system to any sensor or transducer. The recorders combine an industrial-grade computer, A/D card, and any assortment of plug-in signal conditioners.

The 3010-AC operates from AC power, automatically switching from 90 260 VAC, and from 40 to 400 Hz line frequency in any combination. The 3010-DC operates from DC power, from 9 to 32 VDC, and includes an internal UPS that keeps the system running for up to 5 minutes without power. Both units' CPU board, RAM, hard drive, A/D card, and other components can be upgraded.

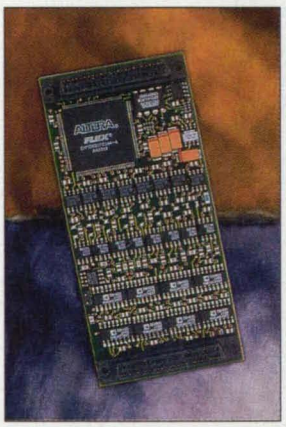
For More Information Circle No. 730



Cole-Parmer Instrument, Vernon Hills, IL, offers a Honeywell® **digital data recorder** that uses a single pen to produce a chart, and chart data and up to four traces on blank, heat-sensitive paper. The microprocessor-based recorder allows the four traces to share the same timeline, eliminating errors due to pen alignment offsets.

Printed chart data such as range markings, engineering units, digital values, time/date, and channel identifiers make the chart application-specific. The recorder features a password-protected lockout that prevents unauthorized changes to configurations and calibrations. The unit accepts DC voltage, current, thermocouples, and RTD inputs.

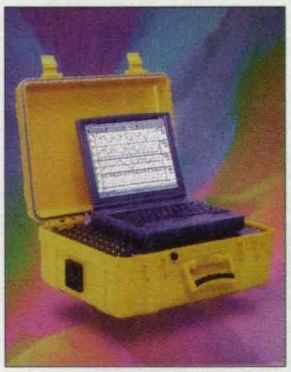
For More Information Circle No. 734



The IP340 IndustryPack **data mezzanine module** from Acromag, Wixom, MI, provides 16 analog inputs that are sampled as two eight-channel banks. Eight A/D converters permit simultaneous conversion of all 8 channels in a bank. A FIFO buffer holds the first bank's data while the second bank is converted. The buffers can hold up to 512 samples. Conversion of each bank requires 8 µS, and all 16 channels can be sampled in 16 µS.

The channels or bank to be converted, timing, scan mode, and other parameters are user-programmable. Up to 80 input channels can be accessed through a single card slot. By installing different modules on a carrier card, users can build a custom I/O board. Analog I/O, digital I/O, serial communication, and other types can be mixed in any combination.

For More Information Circle No. 731



IOtech, Cleveland, OH, offers the WavePort™ portable **PC-based data acquisition systems** designed for field applications. Each unit comes with 16-bit resolution, 1-MHz sampling, external clocking, pulse trigger, and up to 24 channels of signal conditioning. The unit is packaged in a non-conductive case with built-in battery/UPS system. The case accommodates most notebook PCs and power adapters.

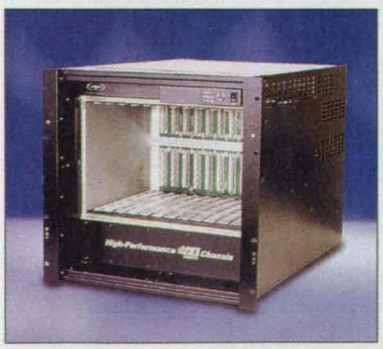
The WavePort/PE provides eight channels of dynamic signal input; the WavePort/V provides 8 to 24 differential input channels with a voltage range of 10 to 30 VDC. Both models include WaveView™ set-up, acquisition, and display software that allows data to be exported for analysis in formats such as Excel, MATLAB, and DADiSP. The units also feature driver support for data acquisition programs such as DASYLab and LabVIEW.

For More Information Circle No. 735

The 3630 Series of compact **data loggers** from Hioki USA Corp., Cranbury, NJ, consists of seven units that are about the size of a credit card, and weigh approximately 2.5 ounces. The models include the 3631-20 temperature/humidity logger, the 3631-20 temperature loggers with either built-in or external sensors, the 3635-20 instrumentation logger, and the 3635-21, -22, and -23 voltage loggers.

The loggers have a recording capacity of 16,000 data points. Nonvolatile memory is used for data storage. A four-step indicator shows the degree of battery consumption, providing an indication of remaining life. By using the 3910-20 communications base, data recorded can be transferred to a PC for processing. The base accommodates up to 16 channels of data.

For More Information Circle No. 733



Tracewell Systems, Westerville, OH, has introduced the cCPI and H.110 Telecom **CompactPCI backplanes** for industrial and data applications. The backplanes combine standard architecture and high-frequency telecommunications design for 6U board heights, and are available for various slot sizes. The cCPI backplanes provide a 64-bit CompactPCI bus, and power terminals are positioned adjacent to the system slot for efficient power distribution and wiring.

The H.110 backplane combines a 32/64-bit compatible CompactPCI bus with an embedded TDM bus, and utilizes a 10-layer board design. The 14-position system header provides logic return and remote sensing for +5, +3.3, and ±12 VDC.

For More Information Circle No. 732

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System Locates Lightning Strikes to Within Meters

Locations are determined from propagation times for electric and sonic fields.

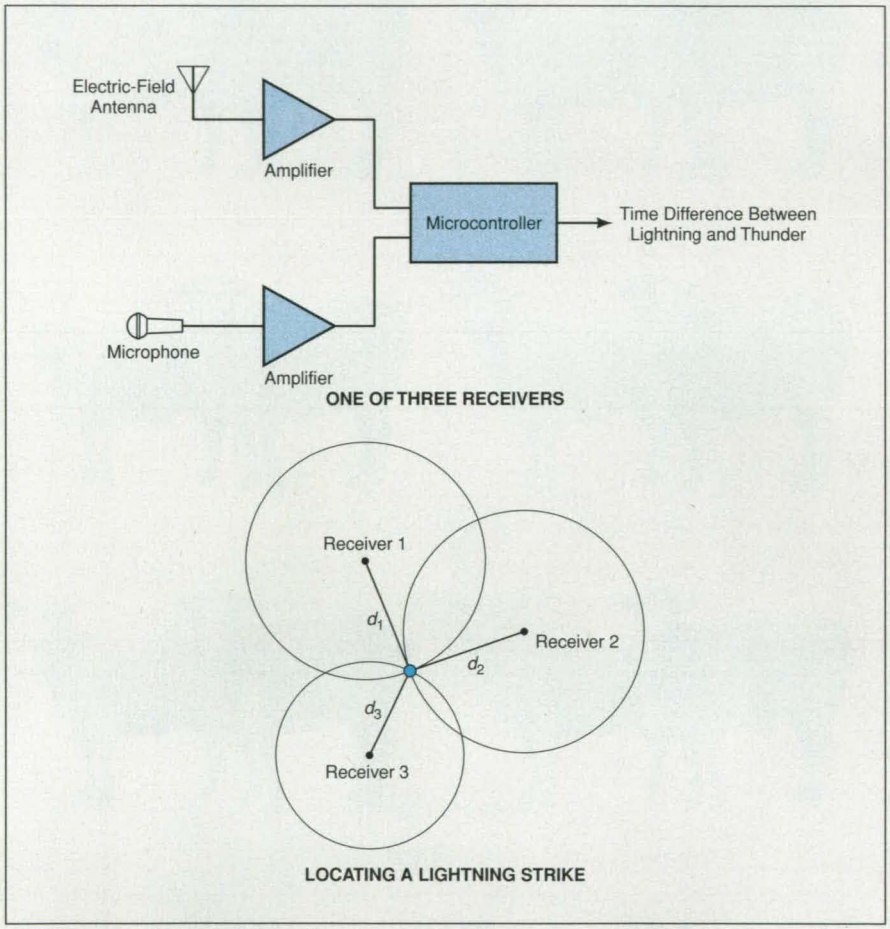
John F. Kennedy Space Center, Florida

A system for determining the locations of nearby lightning strikes from electric-field and acoustic measurements has been developed and built. The system includes at least three receivers, each equipped with an antenna and a microphone. For each strike, the system measures the difference between the times of arrival of the electric-field and sonic (thunder) pulses at each receiver, computes the distance of the strike from the time difference and the speed of sound (about 320 m/s), then uses the distances to determine the location of the strike. The basic concept of this system is thus a variant and extension of the time-honored concept of estimating the distance of a lightning strike from the difference between the times of arrival of the visible flash and the audible thunder.

"Nearby" as used here signifies that the receivers and the lightning strikes of interest are located at distances of the order of 1 km from each other. Older lightning-location systems cover observation areas with radii of the order of 30 miles (48 km), and typically locate lightning strikes with errors of the order of 0.5 km or more; thus, the older systems do not locate strikes accurately enough for purposes of assessing actual or potential damage by lightning to specific structures and pieces of equipment. The developmental system locates strikes to within errors of the order of a meter.

Unlike in some other systems, there is no need for expensive, high-speed waveform digitizers. Instead, the leading edge of the electric-field pulse detected in each receiver is used to start a timer, and the leading edge of the thunder pulse arriving at the same receiver is used to stop the timer. A microcontroller in each receiver transmits the time thus measured to a processing station, where the times are converted to distances that are used to compute the location of the lightning strike (see figure).

The accuracies achievable by older systems and by this system can be compared via consideration of the time-measurement problem. Given that the applicable speed in this system is the speed of sound, even a timing error as large as 1 ms in this system would result in a distance error of only about 0.3 m. However, in a typical older system based on the speed of light, the allowable timing error to achieve such accuracy in distance would be only about 1 ns.



The **Distances of Three Receivers** from a lightning strike is computed from the speed of sound and the times for propagation of thunder to the receivers. The location of the strike is identified as the intersection of radii equal to these distances.

Thus far, only one receiver has been tested. It has been shown to be capable of measuring the distances to lightning strikes. Optionally, the fully developed system could contain more than the minimum of three receivers needed to determine the location of a lightning strike unambiguously under ideal conditions. The additional receivers could be used to enhance accuracy under nonideal conditions. By use of a suitable algorithm, the partly redundant data from more than three receivers could be used to resolve uncertainties introduced by wind and by echoes from nearby objects. The wind problem is especially important because in the presence of wind, the equal propagation-time distance contour around each receiver becomes distorted from a circle.

This work was done by Pedro J. Medelius, formerly of I-NET, Inc., for **Kennedy Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373. Refer to KSC-11992.

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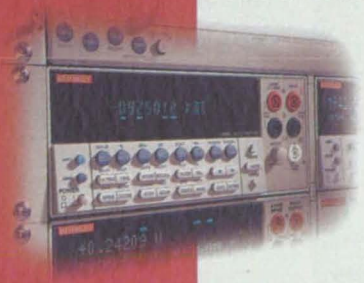

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• AC volts	100nV – 750V	100nV – 750V	100nV – 775V	100nV – 775V
• Ohms	100μΩ – 120MΩ	1μΩ – 120MΩ	1μΩ – 1GΩ	100nΩ – 1GΩ
• DC amps	10nA – 3A	1nA – 3A	10pA – 2.1A	10pA – 2.1A
• AC amps	1μA – 3A	1μA – 3A	100pA – 2.1A	100pA – 2.1A

For More Information Circle No. 544

Flip-Chip W-Band Amplifier: a Prototype of Q-MMICs

Q-MMICs offer an economical alternative to MMICs.

NASA's Jet Propulsion Laboratory, Pasadena, California

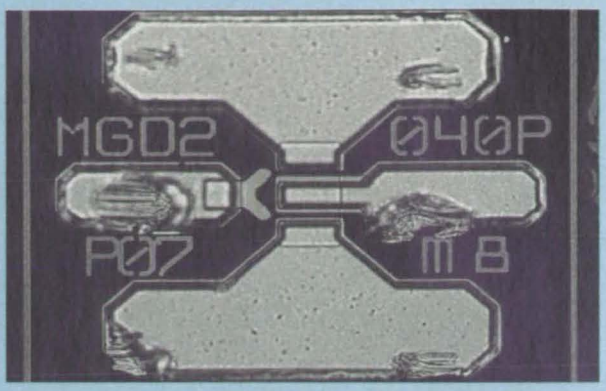
A prototype W-Band, low-noise amplifier has been fabricated by bump-bonding a high-speed, low-noise InP high-electron-mobility (HEMT) transistor onto the previously fabricated passive portion of the amplifier circuit on a GaAs substrate (see figure). The passive portion of the circuit can be regarded as a monolithic microwave integrated circuit (MMIC) that differs from a complete MMIC amplifier only in its lack of a single active device (the HEMT). Therefore, the bump-bonded combination of the active device and the passive portion of the circuit is characterized as a quasi-monolithic millimeter-wave integrated circuit (Q-MMIC).

Heretofore, it has been necessary to resort to expensive custom fabrication of MMICs to satisfy requirements for special-purpose millimeter- and submillimeter-wave circuits that have not been commercially available. In comparison with MMICs, Q-MMICs offer the potential advantages of lower cost and greater design flexibility, in the following respects:

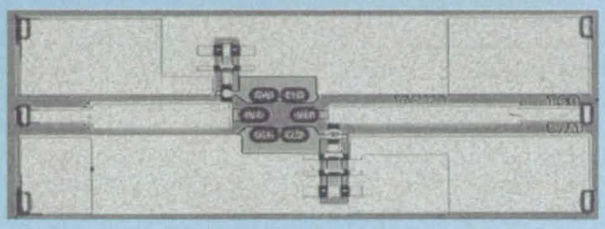
- Part of the reduction in cost is attributable to the conservation of expensive semiconductor area for the fabrication of active devices, in conjunction with the use of cheaper substrates for the more expansive passive circuitry.
- One can ensure higher circuit overall performance and production yield by testing components prior to assembly and bonding.
- This approach affords the flexibility to mix and match discrete active devices with more-easily-fabricated passive circuits and circuit components to create custom high-performance circuits.
- Because the discrete active devices and the passive circuits are fabricated separately, the subprocesses for fabricating each component can be less complex, and thus the overall fabrication process can be simplified.
- By bump bonding, one can hybridize the best-available active devices with passive circuits. In so doing, one can take advantage of (1) the flexibility afforded by the use of discrete microwave integrated circuits, (2) the performance advantage of MMIC's, (3) short design and fabrication times, (4) low costs of fabrication, and (5) uncompromised frequency performance.

In order to make the present flip-chip (bump-bonding) approach viable, it was necessary to solve two major problems. The first problem was to minimize parasitic millimeter-wave resonances associated with the metal bonding bumps. The solution of this problem was simply to make the bumps smaller than they had been made previously. The reduction in parasitic resonances associated with the bumps enables the amplifier circuit to operate at higher frequencies.

The other problem was to make it possible to handle the HEMTs by use of a conventional vacuum chuck. These particular HEMTs were small enough to pass through the vacuum hole in the collet on the vacuum chuck. It was necessary to fabricate a collet adapter with a vacuum hole only 50 μm wide; because a bit for drilling such a narrow



HEMT



PASSIVE PORTION OF AMPLIFIER CIRCUIT

An **InP HEMT Like the One Shown at the Top** was bump-bonded onto the passive portion of the amplifier circuit. Near the center of the passive circuitry are six Au/Sn bumps for fluxless bonding with the HEMT. The six marks on the contact pads are not bonding bumps but, rather, marks left by routine screening with wafer probes.

hole does not exist, the collet adapter was micromachined from silicon. The collet adapter was also refined by making the hole in a pedestal on which several discrete devices could be held closely together for bump bonding onto the same circuit. This refinement makes it possible to assemble more complex circuits that contain multiple discrete devices — for example, a multistage amplifier.

In a performance test covering the frequency range from 85 to 120 GHz, the prototype W-band amplifier was found to operate with a peak gain of about 6 dB at a frequency at 91 GHz, falling off to about 0 dB at 117 GHz. The highest previously published operational frequency for an amplifier fabricated by bump bonding a discrete active device onto a passive circuit was about 60 GHz.

This work was done by Paul Pinsukanjana, Lorene Samoska, Todd Gaier, R. Peter Smith, Alexander Ksendzov, Michael Fitzsimmons, and Suzanne Martin of Caltech and Richard Lai of TRW for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20650

Technology Forecast

This month's technology forecast for the test and measurement industry is contributed by Peter M. Ostrow, President and CEO of TestMart, San Bruno, CA. Peter discusses how e-commerce will affect the efficiency and effectiveness of test and measurement.

The venerable test and measurement industry has been through dramatic changes in the past few years. Manufacturers have begun to need more effective and efficient ways to reach and serve their customers. Equipment users are following new rules to locate and purchase general-purpose and specialized test equipment in a cost-efficient and timely manner. Distributors, brokers, and independent manufacturer sales representatives are redefining themselves and reassessing the value they create and the costs associated with their businesses.

Customers need not be "major accounts" or reside in central locations to be served with product, price, and availability information because the Internet is everywhere for everyone.

An innovative answer to each of these challenges is a net marketplace, where buyers, sellers, and all interested members of the industry meet to exchange information and conduct business. This new e-commerce marketplace creates a new set of rules for the marketing, purchase, use, and sale of test equipment.

The Marketplace

It is important to approach the market from the engineer's perspective — providing information to help them better understand and solve their test or measurement problem, defining product categories for equipment they need, and illustrating what parameters are important to reach a product category decision. Until recently, acquiring that information on a specific instrument, whether an oscilloscope or a signal generator, meant spending hours "normalizing" specifications, contacting numerous, wide-ranging sources, and evaluating disparate acquisition options.

Today, the Internet gives us the power to satisfy each of those needs with a single web site. Application assistance from experienced engineers and parametric search tools can be provided that enable engineers to search and create side-by-side comparisons across the thousands of available products, and identify engineering equivalents across the hundreds of test and measurement manufacturers. The same site can give engineers and corporate purchasing officers information to determine whether to buy, rent, or lease new, used, or refurbished instruments, as well as to access data on pricing, availability, delivery method, condition, warranty, and service agreements.

Users also can establish which manufacturers sell direct and which sell through independent representatives, what products distributors sell, and why some channels discount where others do not. They also can consult the site to confirm quoted delivery times, determine the value of old equipment, and find out if they're getting top dollar in trade-ins or resale.

A test and measurement net marketplace can answer all these questions clearly and accurately, and enable the user to complete the transaction in a secure, neutral, and easy-to-use environment.

The New Rules

Rule #1: *Universal — Serves all manufacturers and all customers.* The Internet has become nearly universal — almost every manufacturer has a web site, and most test equipment customers use the Web at work. But a site is only as good as the information and access it provides. No single manufacturer or distributor web site can help the customer find who carries a product, compare it with competing products, determine price and availability, and order it securely online.

A neutral site, however, complements manufacturers' marketing activities. Unbiased product comparisons make customers aware of manufacturer's products. Electronic data sources and the order entry process can be coordinated with sales channels to avoid the cost of redundant marketing systems. A net marketplace is an effective marketing vehicle for new products, reconditioned products, demo equipment, and excess inventory. Customers are no longer excluded by limitations of sales channels or the cost of marketing because the site serves customers large and small. Customers need not be "major accounts" or reside in central locations to be served with product, price, and availability information because the Internet is everywhere for everyone.

Rule #2: *Affordable — Lowest cost distribution channel.* E-commerce offers many benefits to buyers and sellers. But the cost to maintain a viable web site that presents product, pricing, and availability information, in addition to accepting and tracking orders, is estimated at over $1 million per year, and rising. That puts e-commerce beyond the reach of any small manufacturer, and even beyond the tight budgets of many larger ones. Most firms would also need to develop expensive electronic back offices to support sites of their own.

The presence of a definitive test and measurement commerce and information site means any manufacturer can afford to participate in a best-in-class e-commerce system that is centrally located and securely hosted. The manufacturer saves the cost of developing its own site, gains access to a broader range of customers, avoids channel conflicts, lowers distribution costs, and provides customers with the information they need. Distribution costs also can be reduced.

Rule #3: *Neutral — Reliable, unbiased product comparisons.* An effective, neutral commerce and information site presents normalized, unbiased data that lends product exposure to manufacturers and gives customers the power to make informed purchase decisions.

Rule #4: *Convenient and Secure —Price and availability online.* Test and measurement professionals need more than equipment performance data. An effective commerce and information site must be a central online source of reliable ordering information. Price and availability data must be updated by manufacturers in real time using secure and controlled remote access. A safe, secure environment must protect the information without impeding the process.

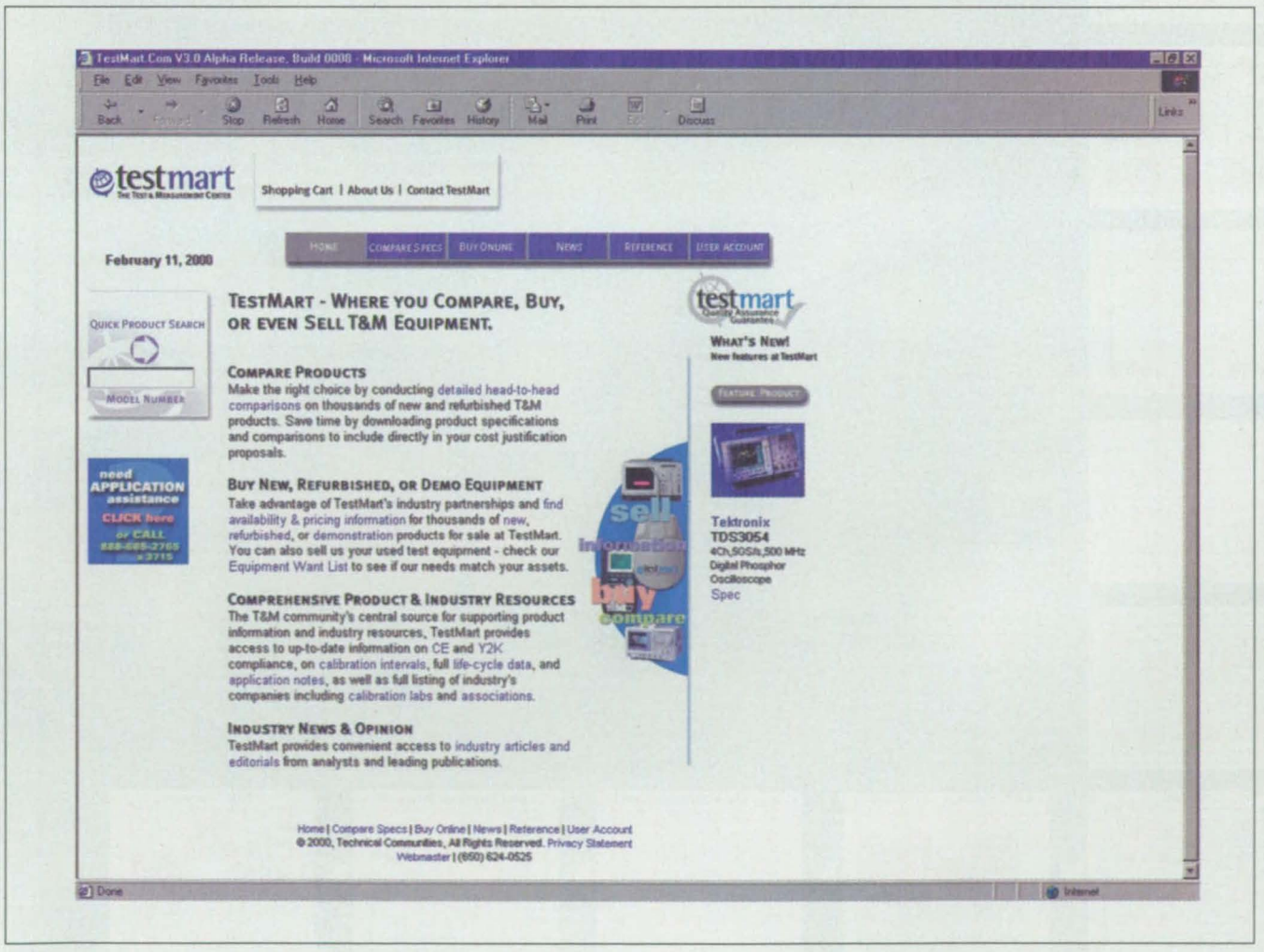
Rule #5: *Informative meeting place.* An effective web site can centralize vast amounts of content and facilitate relationships, and a true test and measurement net marketplace will be a source of information and ideas from leading publishers and analysts for the entire industry. By consolidating news articles, applications notes, white papers, and reference libraries, as well as links to industry sources such as professional associations and calibration libraries, the net marketplace will be an Internet entry point of choice for anyone interested in test and measurement.

Rule #6: *A secondary market for asset management.* An effective commerce and information site can help customers better manage their test equipment assets. Customers can explore rental and lease options on the site for products they need for short periods or prefer not to own. The site also can offer a unique, low-cost outlet for recycled, used, and excess inventory. Customers and manufacturers who have surplus assets can offer them for sale in a safe and secure environment; a substantial improvement over transient, ad-hoc brokerage and auction activities.

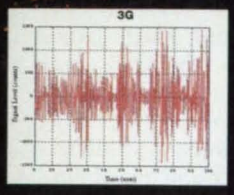
The Definitive Marketplace

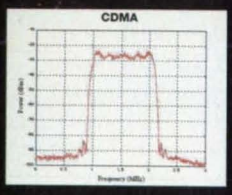
A true test and measurement net marketplace will serve leaner, more focused manufacturers who must reach large numbers of new customers located throughout the world. It will satisfy customers with convenient, reliable access to data they can use to compare products, accurate and timely price and availability information, and provide an easy, secure way to purchase what they need, when they need it. It supports wise asset management with a viable secondary market for both buyers and sellers. Most importantly, it will be accessible to everyone in the test and measurement marketplace.

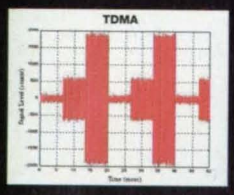
For more information, contact the author at TestMart, 851 Traeger Ave., San Bruno, CA 94066; Tel: 888-665-2765; Fax: 650-624-0535; e-mail: postrow@testmart.com; or visit www.testmart.com.

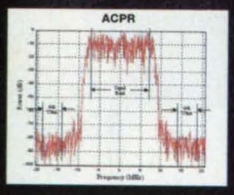


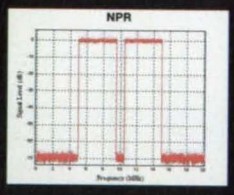
Imagine a Test & Measurement System That Does All This

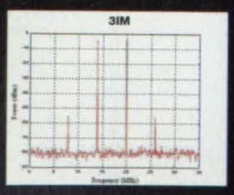


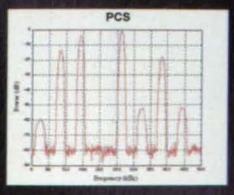


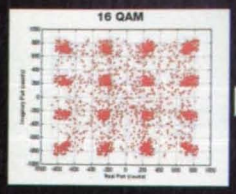


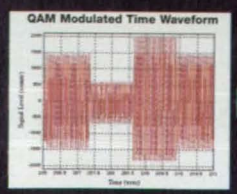


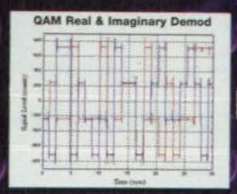


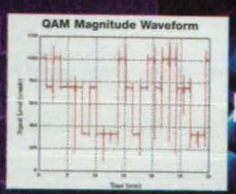


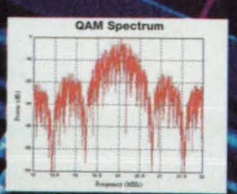












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Measuring NO and OH Concentrations at High Pressure

An optoelectronic laboratory apparatus could be developed into a portable instrument.

John H. Glenn Research Center, Cleveland, Ohio

An apparatus based on line-of-sight resonant absorption of ultraviolet light yields measurement data from which one can calculate the concentrations of nitric oxide (NO) and of hydroxyl radicals (OH) in a laboratory flat flame at a pressure up to 30 atm (≈3 MPa). The basic measurement principle is distinct from the principles of laser-induced fluorescence and other laser diagnostic techniques; hence, the data generated by this apparatus could provide independent verification of data from laser-based instruments.

Line-of-sight resonant absorption of ultraviolet light has been in use at least since 1976; however, until now, it had not been experimentally verified to be useful for determining NO and OH concentrations at pressures above 2 atm (≈0.2 MPa). The high-pressure-flame regime of the present development was chosen because it is representative of conditions at the exit of advanced combustors. The design of the apparatus and the measurement principle are simple enough that it should be possible to develop the apparatus into a portable optoelectronic instrument that could be set up in combustor or engine test cells.

In the apparatus (see figure) a water-cooled hollow-cathode lamp generates ultraviolet light, which is collimated and directed through a test cell that contains the flame to be probed. The portion of the collimated beam that remains after passing through the test cell then enters a fiber-optic cable, through which it travels to the entrance slit of a computer-controlled grating spectrometer equipped with a linear array of 1,024 photodiodes at its output plane. The spectrometer measures the spectrum of light that has passed through the test cell, at wavelengths from 208 to 280 nm (for NO) or 300 to 330 nm (for OH) with a spectral resolution of 0.3 nm.

For measuring the concentration of NO, a glow discharge in flowing air at a pressure of 5 to 10 torr (≈0.7 to 1.3 kPa) is created in the hollow-cathode lamp. The light from this discharge includes discrete emission spectral lines generated by the recombination of O and N with N_2 and O_2. Thus, the emitted light includes components that resonate with the absorbing species of interest. Although one could use a continuum light source (at least in principle), resonant absorption offers the advantage of a greater signal-to-noise ratio. For measuring the concentration of OH, the lamp is operated in a similar manner except that the glow discharge is created in an atmosphere of argon saturated with water.

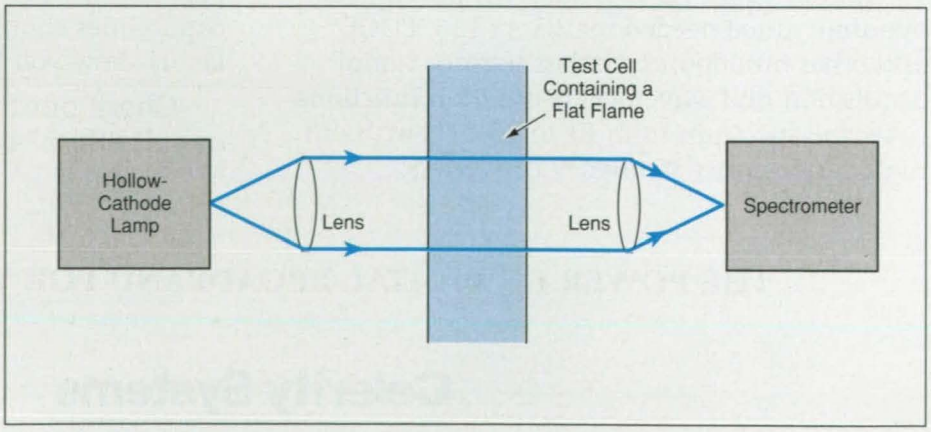
The spectrum of transmitted light is well approximated by a mathematical model of transmissivity as a function of wavelength, the temperature of the flame, the length of the optical path through the flame, and the concentration and optical-absorption characteristics of the gas species (NO or OH) of interest. The model was developed to nearly its present form in 1980 and was refined, for use in the present application, by incorporating terms to account for shifting and pressure broadening of spectral lines of both NO and OH.

In use, an assumed value of the concentration of the species of interest is inserted in the model of transmissivity along with the known values of the other quantities and the model is convolved with a spectrometer-slit function to obtain a predicted spectrometer output. This computation is repeated, if necessary, using different values of assumed concentration. The concentration of the species of interest is then deemed to equal whichever value of assumed concentration results in the best match between the predicted and actual spectrometer outputs.

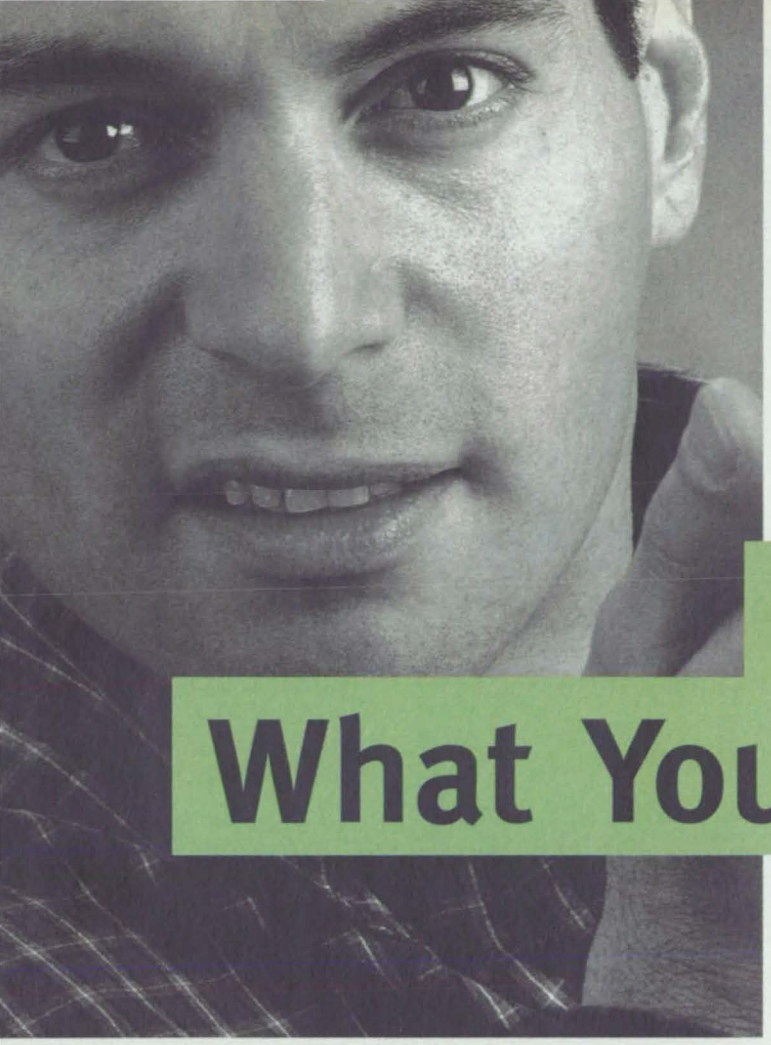
In tests, the apparatus was used to measure spectra during operation of the cell with flames at two different fuel/air mixture ratios (fuel concentrations of 0.98× and 1.3× stoichiometric) and at several pressures from 1 to 30 atm. (≈0.1 to 3 MPa). Concentrations of NO and OH were measured independently by a conventional gas-sampling technique. The absorption spectra measured by the apparatus agreed, within 25 percent, with absorption spectra predicted by the mathematical model. Continuum absorption in hot oxygen was found not to be strong enough to interfere significantly in interpretation of the data on absorption in NO.

This work was done by D. S. Liscinsky, B. A. Knight, and J. A. Shirley of United Technologies Research Center for **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Test and Measurement category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16914.



Ultraviolet Light that resonates with absorption spectral lines of a gas species of interest is directed through the test cell. The spectrum of transmitted light is measured and processed to determine the concentration of the species of interest in the test cell.



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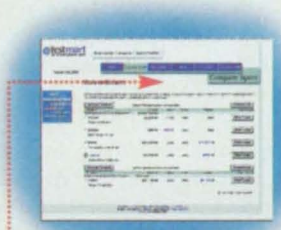

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Automated Apparatus for Testing Gyroscopes

Except for initial setting of conditions, the entire testing process is automated.

NASA's Jet Propulsion Laboratory, Pasadena, California

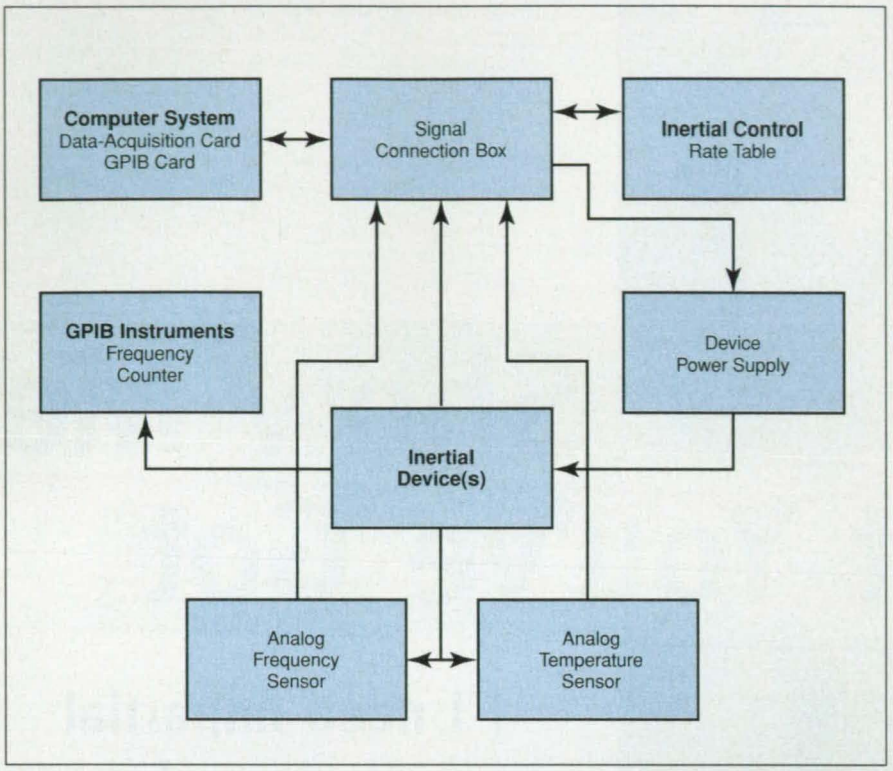

Figure 1. This **Simplified System Diagram** depicts the major functional blocks of the Gyroscope Automated Testbed.

The Gyroscope Automated Testbed is a computer-controlled apparatus designed primarily for automated testing of vibratory gyroscopes. It can also be used to test other devices: By changing testing-system/tested-device interface circuitry that is part of the apparatus, one can set up the apparatus to test nonvibratory gyroscopes. The apparatus can also be used as a general-purpose noise-analysis system for characterizing a variety of devices in addition to gyroscopes.

Heretofore, it has been necessary to resort to a manual process to test gyroscopes. The process is very time-consuming and requires expensive test equipment. The present apparatus automates most of the process for a fraction of the cost.

The apparatus (see Figure 1) is based on a Pentium II computer with a 16-bit data-acquisition card and a GPIB (general-purpose interface bus) interface card. Custom software for control of testing and analysis of data has been developed in Visual Basic. The system is fully automated and only requires an operator to initially set the desired testing conditions. The software can perform a rotational-response test, noise characterization test, and a power-cycle stability test. Data analysis is performed on the acquired data to characterize the rotational response and power-cycle stability (see Figure 2 on facing page). A Green chart and a plot of the power spectral density (PSD) are generated to characterize the noise properties of the device being tested. Device drift and Green charts can be corrected (linearized) by any other sampled data set (i.e., the drift data can be corrected for increasing temperature over the duration of a test). A report, which consolidates the results into a convenient document, is generated automatically upon completion of all tests. The software includes provisions for selecting the tests to be performed, setting test parameters, saving acquired data to a file, generating real-time output displays, testing under manual control, and deriving noise characteristics from previously acquired data.

This work was done by Christopher Evans and Roman Gutierrez of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Test and Measurement category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20612.

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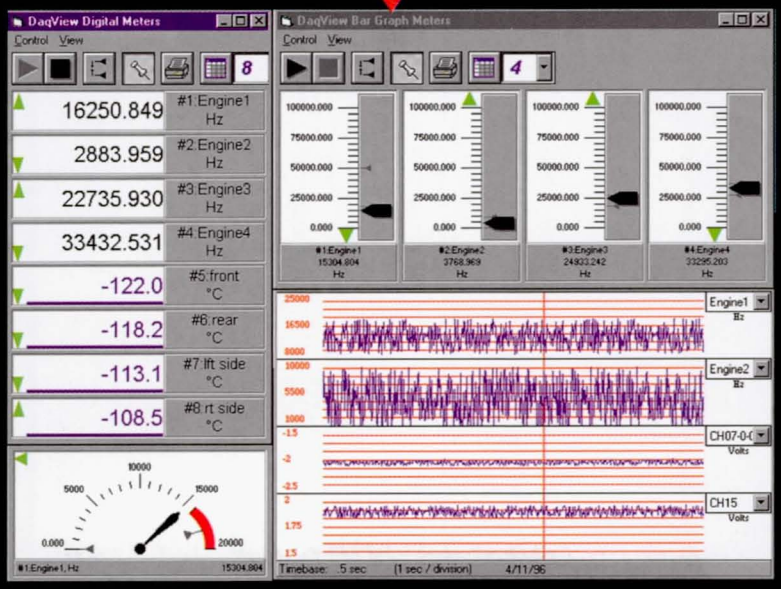

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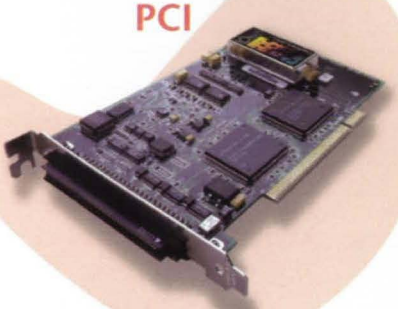

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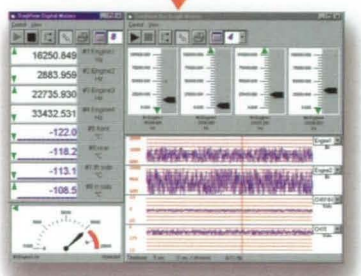

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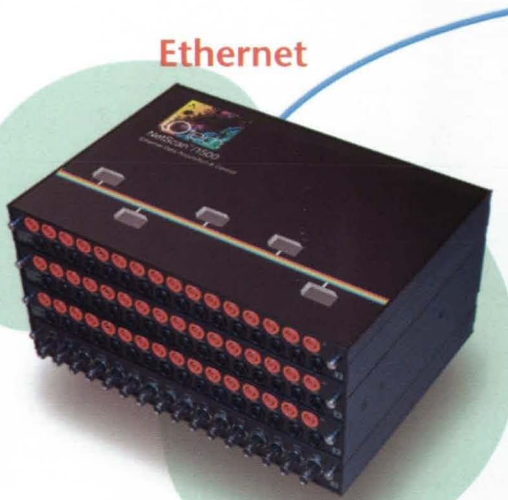

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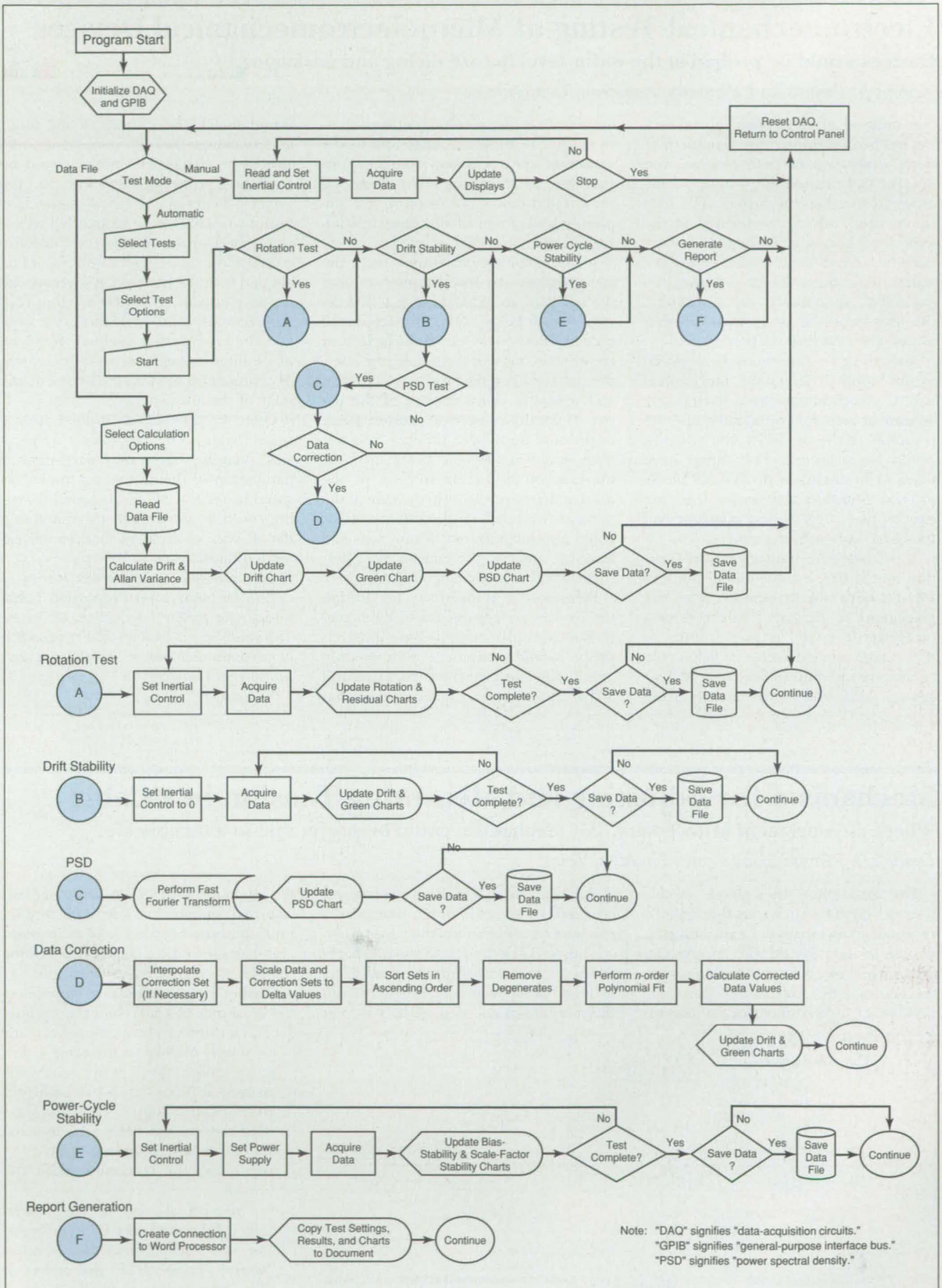


Figure 2. This **Flow Chart** represents the automated test procedure implemented by the custom software in the Gyroscope Automated Testbed.

Electromechanical Testing of Microelectromechanical Devices

Devices would be probed at the wafer level before dicing and packaging.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of electromechanical testing has been proposed for general diagnosis, evaluation of performance, and burn-in (accelerated life testing) of microelectromechanical devices. The tests would ordinarily be performed at the wafer level; that is, after the devices have been fabricated on wafers but before the wafers have been diced and the dies packaged. Alternatively or in addition, the tests could be performed at other stages of the fabrication process.

According to this method, a probe would apply a specified mechanical and/or electrical stimulus to each device (sensor or actuator) on a wafer, and the response of the device to the stimulus would be measured. The things most likely to be useful as probes are piezoelectric transducers because they are easy to use, rugged, and compact and they have wide dynamic ranges.

A piezoelectric transducer can function as a driver, a force-measuring sensor, or both simultaneously. The displacement or change of thickness of a piezoelectric crystal is proportional to the voltage applied across it. If the voltage applied to a piezoelectric crystal oscillates sinusoidally with time, then the amplitude of the acceleration is proportional to the applied voltage and to the square of the oscillation frequency. In that case, the force exerted by the crystal on a tested device is related to the amplitude and phase of the electrical impedance of the crystal.

If sinusoidal excitation were used, the ratio between the force applied to, and the resultant acceleration of, a tested device would be a complex impedance quantity that could be characterized as the effective mass of the device; the effective mass would reflect the mass, stiffness, and damping characteristics of the device. If the device were an accelerometer or pressure transducer, then the effective mass would include the proof mass (in the case of the accelerometer) or the mass of the diaphragm (in the case of the pressure transducer); the effective mass could also include part of the mass of a housing and/or the masses of other structures that participate in motion.

Piezoelectric transducers for testing the devices on a wafer could be assembled into a probe station. Typically, each probe would contain a piezoelectric crystal that had a specified thickness and a flat and smooth contact surface that would match the portion of the wafer area occupied by a die containing a device to be tested. The probe would be fixed to a probe platform with an elastomeric material. Electrical-connection buttons would also be suspended in the elastomeric material. The piezoelectric crystal and connection buttons would be aligned with the die before lowering the probe platform and thereby compressing elastomer and preloading the crystal. The compressive preload would be made large enough to prevent the loss of compressive load on the crystal at any stage of the test process.

Once the preload was applied, testing could begin. The resonance frequencies, damping rates, and performance parameters of the devices on the wafers could be measured. Accelerated life testing could be performed by stimulating the devices at their resonances for extended times.

This work was done by Frank Hartley of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Test and Measurement category.*

NPO-20563

Mechanism for Adjusting and Measuring Tension in a Cable

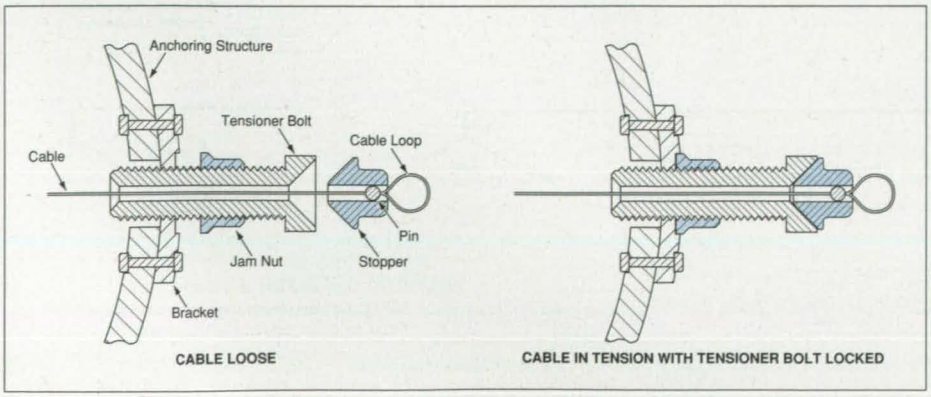
Where measurement is necessary, this mechanism could be preferable to a turnbuckle.

Lyndon B. Johnson Space Center, Houston, Texas

The figure illustrates a simple mechanism designed for anchoring one end of a cable on a structure and for adjusting the tension in the cable. Unlike turnbuckles and other conventional cable-tensioning mechanisms, this mechanism also facilitates direct measurement of the tension in the cable. Several of these mechanisms are used in concert in order to suspend a structure for thermal isolation.

The bracket is used to secure the mechanism to the anchoring structure. The near end of the cable is threaded through the mechanism and tied off in a loop at the pin in the stopper. The tensioner bolt is turned counter-clockwise in the bracket until the bored conical hole at its outer end mates with the conical surface of the stopper, placing the cable in tension.

Further counter-clockwise rotation of the tensioner bolt increases the tension. The tension can be measured directly by simply pulling on the cable with a force gauge; the tension equals the measured force that is just sufficient to unseat the stopper. Once the specified tension has been achieved, the tensioner bolt is locked in place by tightening the jam nut against the bracket.



The **Tension in the Cable Is Adjusted** by turning the tensioner bolt. The tensioner bolt can be locked by use of the jam nut. The tension can be measured by pulling on the cable loop.

This work was done by Ross G. Iacomini of **Johnson Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Test and Measurement category.*

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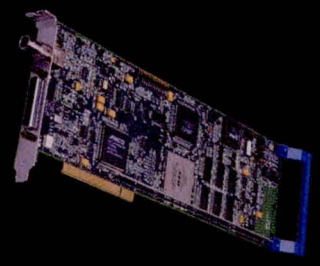

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Software Improves Management of Dynamic Memory

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Marshall Space Flight Center, Alabama

The Dynamic Memory Management System (DMMS) is a computer program that was developed in response to some major shortcomings of dynamic-memory-management subsystems of typical operating systems. It is designed for use with the VxWorks operating system, but is easily ported to other operating systems.

The shortcomings in question are the following:

- Memory fragmentation — the waste of storage space that occurs when many small blocks of storage space (buffers) are scattered randomly throughout a memory pool and the memory-management component of software is unable to coalesce these small buffers into a larger buffer;
- Memory leak — progressive loss of storage space that occurs because an error in the storage-allocation component of software causes a failure to deallocate memory space that is no longer needed for the task at hand;
- Limited or no visibility into usage of dynamic memory; and
- Unreported overwriting of allocated memory buffers.

DMMS is designed to overcome these shortcomings while maintaining a simplistic interface and providing rapid execution. DMMS offers the advantages of the core memory-partition-manager component of VxWorks; namely, ease of implementation and rapid (taking tens of microseconds or less in typical cases) allocation and deallocation of buffers. DMMS enables monitoring of usage of dynamic memory and integrity of dynamic memory at buffer-release time; these features enable the user to fine-tune DMMS to obtain the highest possible performance and to become aware of gaps in the integrity of dynamic data buffers.

Going beyond what is offered by VxWorks, DMMS offers the following additional features:

- Memory is allocated according to the buddy system instead of a first-fit algorithm. In the buddy system, buffers are allocated in sizes that are always powers of two, so that they can readily be joined and/or split. Unused smaller buffers that have been made by splitting larger ones are made available for allocation. The net effects of the buddy system are to prevent fragmentation of the memory pool and to contribute to rapidity of allocation and deallocation.
- Freed blocks are coalesced only when necessary and only to the extent necessary. This practice offers a timing advantage over the older practice of coalescing buffers as much as possible whenever a buffer is freed.
- The user is notified of writing data past the end of a buffer when deallocation of the buffer is requested. During development, such overwriting is a frequent error that is sometimes difficult to identify without the help of this feature of DMMS.
- The identity of the task that requested a dynamic buffer is made known. This information can be helpful in finding and correcting a software component that causes memory leak.
- Information on the "high-water usage" (maximum number used) of buffers of each size is made available. This information can be used in fine tuning to reduce the size of the overall dynamic buffer pool.

This work was done by Ron Phillips of Sverdrup Technology, Inc., for **Marshall Space Flight Center**. *For further information, please contact Sverdrup Technologies, Inc., 620 Discovery Drive, Huntsville, AL 35806, Telephone No. (256) 971-9425.*

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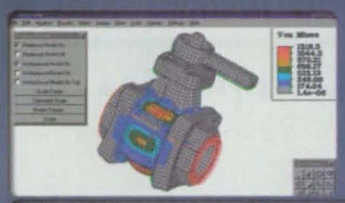
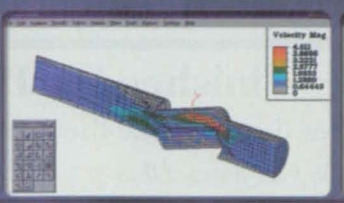
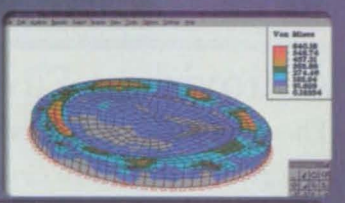


Linear Static Stress - Algor's linear static stress product enables you to capture complex assemblies, such as this valve assembly, from a CAD solid modeler and run a finite element analysis using fast solver technology. Typical loadings are pressure, acceleration, temperature, force and prescribed displacements.

Steady Fluid Flow - Prescribed velocities and pressures provide the loading for this 3-D steady fluid flow analysis of a pipe with a gate valve. Algor's multiple load curves allow for easy data entry for adding loading such as gravity.



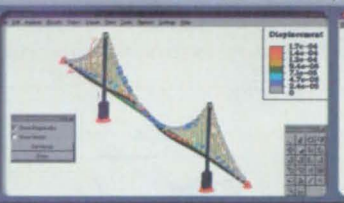
Unsteady Fluid Flow - Unsteady fluid flow of this ball valve system was analyzed using a 3-D CAD solid model. Algor's unique processor solves for velocities and pressures throughout the dynamic event, using a specialized meshing algorithm for high velocity gradients.



DDAM - Algor's Dynamic Design Analysis Method enables you to analyze the shock response at the mountings of shipboard equipment such as watertight doors, masts, propulsion shafts, rudders, exhaust uptakes and portholes, as shown above.

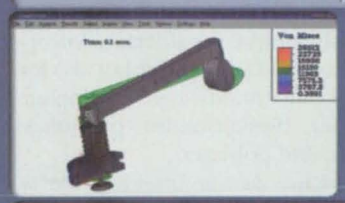
Transient Heat Transfer - The dynamic effects of a transient heat transfer analysis were needed for the time-dependent temperature loading of this heat sink assembly. Algor's multiple load curves for various loading conditions allow for the simulation of the thermal event.

Nonlinear Static Stress - Algor's nonlinear product helps to accurately predict large deformation and large strains caused by static loading. As seen by this water tank, buckling of a structure is one type of failure that can be exposed.

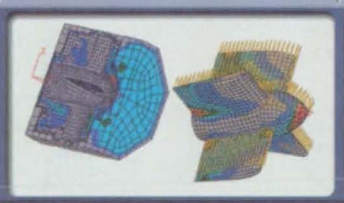


Linear Dynamic Stress- A modal analysis is one of the linear dynamic stress analyses performed on this suspension bridge. Failure can occur when the loading frequency is at the structure's resonant frequency. Algor's linear dynamic analyses accurately predict these frequencies and dynamic effects.

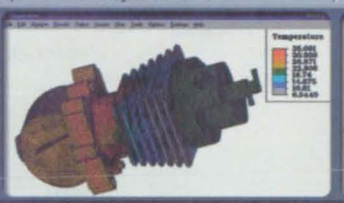
Mechanical Event Simulation (MES) with Nonlinear Material Models - Algor's MES extends full dynamic analysis capabilities to large strain/deformation analyses of nonlinear materials, as shown by this landing gear assembly. Kinematic elements can be used for quicker processing.



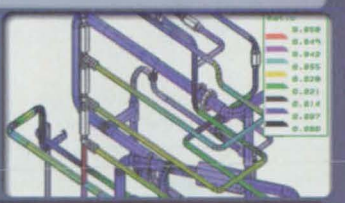
Mechanical Event Simulation (MES) with Linear Material Models - Algor's MES with linear material models allows you to represent a dynamic analysis while solving for kinematics, deflections and stresses of the structure. Analyses using large CAD assemblies, such as this rocker arm assembly model, can be expedited by using kinematic elements.



Multiphysics - Algor's multiphysics products enable you to combine multiple analysis types into one event. Resultant forces from flow around this turbine were calculated and then projected onto the object for a structural analysis. Other multiphysics capabilities include combining heat transfer with fluid flow, heat transfer with static/transient stress and heat transfer with fluid flow and stress.



Steady-State Heat Transfer - Algor's steady-state thermal processor helps predict temperature distribution due to thermal loading. Loading such as convection, radiation, conduction, applied temperatures and surface heat fluxes can be added to an analysis for fast, accurate results. In the case of this engine casing, both conduction and convection were part of the analysis of this 3-D solid model.



Piping Design and Analysis - Algor's piping design and analysis product enables you to calculate the deflections and stresses of this plant piping system and then compare the results with ASME/ANSI code allowables. Loadings can include: dead weight, thermal differences, pressure, wind loads, earthquake loads, time history of forces/displacements, response spectrum, natural frequencies and pitch and roll.

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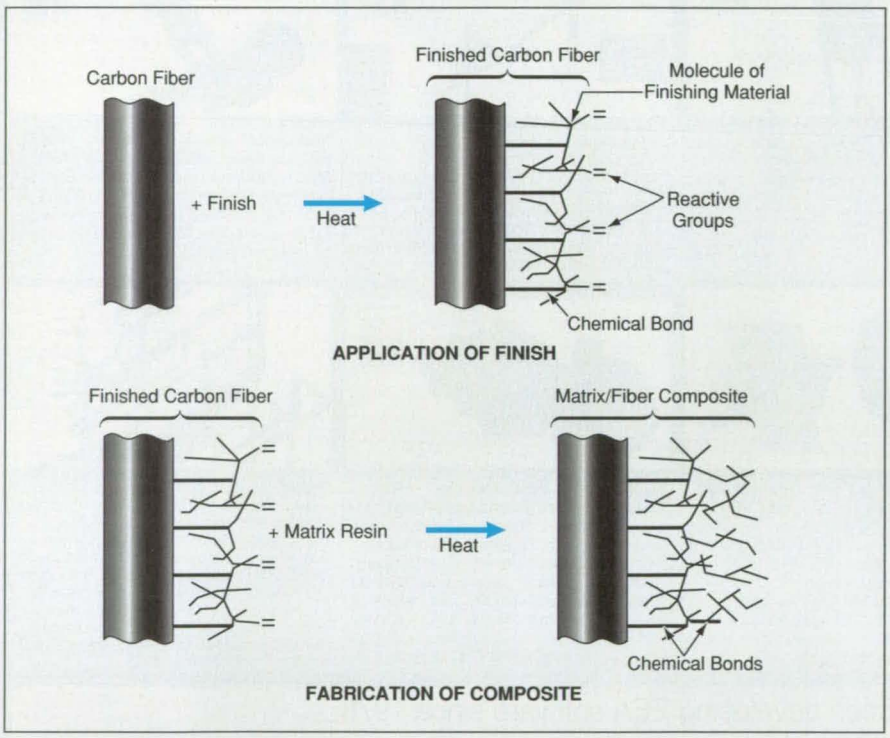
Antioxidant Fiber Finishes for Polyimide-Matrix Composites

These are reactive finishes that increase thermo-oxidative stability.

John H. Glenn Research Center, Cleveland, Ohio

Polyimide-matrix/carbon-fiber composite materials with enhanced thermo-oxidative stability can be made from carbon fibers that have been coated with suitably formulated reactive finishing materials. These finishing materials were developed out of a need to increase thermo-oxidative stability of composite materials for high-temperature applications, and in response to the observation that thermo-oxidative degradation of polyimide-matrix/carbon-fiber composites is dominated by phenomena that occur at matrix/fiber interfaces.



A **Reactive Finish** is applied to a carbon fiber, with which it forms a chemical bond. During the subsequent incorporation of the fiber into a composite material, the finish forms a chemical bond with the matrix.

The figure schematically depicts the coating of a carbon fiber with a reactive finish and the subsequent incorporation of the fiber into a polyimide-matrix/carbon-fiber composite. Reactive coupling agents in the finishing material chemically bond to both the carbon fibers and the polyimide resin. The fiber/finish and finish/matrix chemical bonds increase the durability of the composite material by strongly resisting attack by oxygen, moisture, and solvents. The chemical bonds also increase interfacial strength and resistance to fatigue.

The finishing material includes a resin carrier compatible with the matrix resin. By selection of different carrier resins, it should be possible to formulate other reactive finishes and tailor interfacial properties, not only for polyimides, but also for a variety of other matrix materials, including epoxies, bismaleimides, phenolics, vinyl esters, and polyesters.

This work was done by James K. Sutter of **Glenn Research Center** *and Ronald E. Allred and Larry A. Harrah of Adherent Technologies, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16729.

Enhanced Shield Against Meteoroids and Orbital Debris

This shield significantly decreases the likelihood of loss of a crew and/or spacecraft.

Lyndon B. Johnson Space Center, Houston, Texas

NASA scientists, who are very concerned with the increasing hazard of impacts of orbital debris impact on spacecraft, have designed the "stuffed Whipple" shield — a lightweight, relatively inexpensive alternative to simple aluminum meteoroid/orbital-debris (M/OD) shield. The stuffed Whipple shield features an easily adaptable design that increases protection against hypervelocity impacts (HVIs), without significantly affecting previously formulated designs of spacecraft. The stuffed Whipple shield is critical to the continued human exploration of space, especially to the Space Station, inasmuch as the Station will be operating in low orbit around the Earth and will need shielding against HVIs in order to survive intact and for an appreciable amount of time and continue to safely support human habitation. Scientists project that the number of HVIs from detritus of artificial objects will increase from 2 to 5 percent per year — an increase that could produce devastating results.

The design of the stuffed Whipple shield greatly reduces the risk of loss of a spacecraft crew and/or damage to the spacecraft. It also increases crew efficiency, in that by providing more efficient shielding, it reduces the frequency of both extravehicular and intravehicular activities EVAs and IVAs to effect repairs of HVI penetrations of the outer skin of the spacecraft. It is particularly amenable to introduction in the final or nearly-completed phase of the spacecraft-design effort. The stuffed Whipple shield can be retrofitted to any extant military or commercial spacecraft.

Many previously designed space vehicles are equipped with all-aluminum shields, of a form of Whipple shield, for protection against HVIs. All-aluminum shields offer an improvement over shields of the earliest designs; however, all-aluminum shields were designed for a situation in which an HVI, while always a possibility, seemed a remote likelihood. Indeed, even the earlier Space Station designs were completed before emergence of the awareness of the artificial-debris environment and of the consequent need for greater protection, and at greater cost savings.

As the orbital-debris environment affects more commercial satellites, there will be a need to add lightweight anti-HVI shielding for protection. By virtue of its incorporation of lightweight materials and its easily adaptable design, the stuffed Whipple shield can be used on Space Station pressurized modules and on any spacecraft that typically carries a simple aluminum M/OD shield.

Better yet, the reduction in launch weight afforded by replacing the all-aluminum shield with the stuffed Whipple shield results in an estimated reduction of $345 M in the cost of launch. It is not surprising, therefore, that increased safety and decreased cost equally drive the stuffed-Whipple-shield design for the Space Station.

A stuffed Whipple shield includes front and back sheets and contains lightweight materials (the "stuffing"). The stuffing materials are selected and placed so as to break up large impinging particles, stop small impinging particles, and decelerate debris clouds before they can reach the back sheet. (In the case of the habitable Space Station modules, the back sheets are the pressure shells of the modules.)

A stuffed Whipple shield also offers a secondary support structure, which reduces system costs. This secondary structure is a mesh/Nextel (or equivalent ceramic)/Kevlar (or equivalent aromatic polyamide) blanket that can be supported in a number of ways. For example, it can be held by brackets, frames, or other supports that are modified versions of supports used in the current Space Station design to attach multilayer thermal insulation blankets. Another method of support involves mounting the blanket on a rigid graphite/epoxy or aromatic-polyamide/epoxy panel; the panel is then attached to the previously installed bumper-support structure, where its rigidity can potentially be offset by reductions in the blanket (i.e., the aromatic polyamide portion).

This work was done by Jeanne L. Crews and Eric L. Christiansen of **Johnson Space Center** *and Joel E. Williamsen, Jennifer H. Robinson, and Angela M. Nolen of Marshall Space Flight Center. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

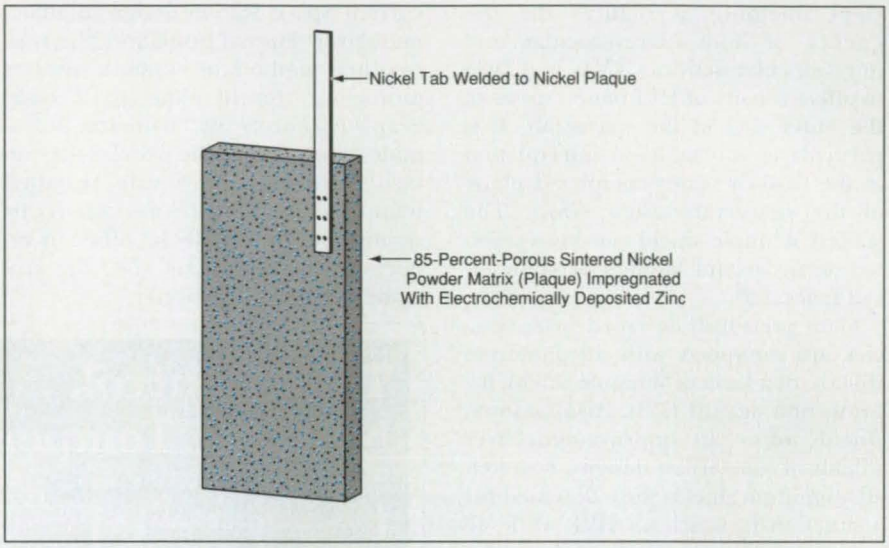
This invention has been patented by NASA (U.S. Patent No. 5,610,363). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22584.

High-Performance Zn Anodes for Ag/Zn and Ni/Zn Cells

Cycle lives are increased and costs are reduced.

Lyndon B. Johnson Space Center, Houston, Texas

Improved zinc anodes for silver/zinc and nickel/zinc rechargeable electrochemical cells have been invented. This invention will increase the usefulness and decrease cycle-life costs of Ag/Zn and Ni/Zn cells in NASA Space-Station-support applications, for which batteries with high energy densities and long cycle lives are needed; examples of these applications include extravehicular mobility unit (EMU) batteries, the EMU portable life-support subsystem (PLSS) backpack batteries, and batteries in portable tools and equipment for extravehicular activities (EVAs). Inasmuch as many of these portable tools and other items of equipment are modified versions of commercial items (portable tools, lights, cameras, recorders, camcorders, radios, communications equipment, cellular telephones, and medical equipment), this invention might also prove beneficial in numerous commercial applications. Similarly, it could offer benefits in military applications, other government applications, and other applications that involve batteries.



A **High-Performance Zinc Anode** includes a porous nickel plaque that maintains its size and shape. The active anode material (zinc) is loaded into the pores.

Two phenomena that limit the cycle lives of Ag/Zn and Ni/Zn secondary cells were unaddressed prior to this invention. These phenomena are (1) gradual changes in the shapes of zinc electrodes and (2) the deposition of zinc as dendrites during recharge.

- Regarding the shape changes: During charge/discharge cycling, the anodes become denser and lose active surface

area. These changes cause progressive losses of capacity and thus of cycle life.

- Regarding the dendrites: These are sharp, needlelike crystals, which can penetrate cell separators and thereby cause internal short circuits.

Either phenomenon can lead to an uncomfortable, even a hazardous situation during a space flight. The invention maintains the integrity of a nickel anode, helping to prevent both of these phenomena. In so doing, it increases cycle life and thereby reduces the cost per cycle.

A typical conventional commercial zinc electrode contains a conductive grid made of perforated or expanded metal (typically copper) sheet. The invention involves a different approach: a zinc electrode according to the invention can be manufactured in a manner similar to that of making cadmium electrodes for aerospace cells. A porous sintered nickel powder matrix (plaque) is loaded with zinc by immersing the sinter in a zinc nitrate solution and electrochemically reducing the zinc. When the resulting anode is assembled into a battery, the form of the anode (see figure) is maintained by the nickel matrix. Even though nickel can give rise to excessive gassing by electrocatalyzing the decomposition of water, the use of nickel nevertheless confers an advantage by reducing the incidence of dendritic shorting and thereby extending cycle life.

Calculations have shown that the energy density of a cell is not impaired by substituting the zinc-loaded nickel-plaque anode for a conventional copper-grid-supported anode. Calculations have also shown that the plaque, when loaded with the same weight of zinc that would be included in a conventional anode, accommodates the increased volume of zinc oxide that is generated during discharge.

It has been suggested in some quarters that high-performance zinc anodes might be improved through use of a copper plaques of the proper porosity. However, there is no substantive evidence that this option would yield a greatly enhanced cycle life or address the shape-change and dendrite issues. Therefore, despite lower porosity (85 percent) of the nickel plaque relative to the 90-percent porosity of copper plaque, nickel plaque was chosen over copper plaque.

This work was done by John E. Casey of Lockheed Engineering & Sciences Co. for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

This invention has been patented by NASA (U.S. Patent No. 5,780,186). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22540.

Tape-Spring Reinforcements for Inflatable Structural Tubes

Tape-springs and tubes help each other resist buckling.

NASA's Jet Propulsion Laboratory, Pasadena, California

Lightweight, inflatable tubular structural components containing tape-spring reinforcements are undergoing development. The basic (without tape-spring reinforcement) tubular components are made, variously, of aluminum laminates or composite materials and are under consideration for use in erecting structures in outer space. They could also be used to erect structures for terrestrial applications in situations in which a greater value is placed in light weight than on strength.

Two types of tape-spring reinforcements have been conceived for this purpose: longitudinal and circumferential. Longitudinal tape-spring reinforcements are made from strips of spring steel or other high-modulus materials with curved cross sections, such as the type of spring strips used commonly in compactly stowable carpenters' measuring tapes. The reinforcements would exploit the well known nonlinear mechanical responses of such tapes, namely: (1) high resistance to buckling while they are straight, (2) the ease with which they can be rolled up once they have been initially flattened, and (3) much stronger resistance to bending or buckling toward the concave-side-out configuration than toward the concave-side-in configuration.

Usually, a thin-wall tube buckles inward first. If one attaches longitudinal curved-cross-section tape springs to the inside of a thin-wall tube at several circumferential positions and orients them with their concave sides facing toward the interior, then the tape-springs help to restrain the tube against inward buckling while the tube helps to restrain the tapes against outward buckling. The net effect is a large increase in the load-bearing capacity of the reinforced tube.

Because the stiffness of a tape-spring decreases as its length increases, it has been proposed to add circumferential reinforcing tape-springs, or other forms of circumferential reinforcement, to long tubes for certain applications. Circumferential reinforcing tape-springs would be fabricated as straight, thin, flat strips. They would be attached to the insides of the tubes. The circumferential reinforcements would also serve as hard attachment points for tubes subjected to lateral loading.

This work was done by Houfei Fang and Michael Lou of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

NPO-20615

Mechanism for Planar Manipulation With Simplified Kinematics

Simple combinations of actuator motions yield purely radial or purely tangential end-effector motions.

Goddard Space Flight Center, Greenbelt, Maryland

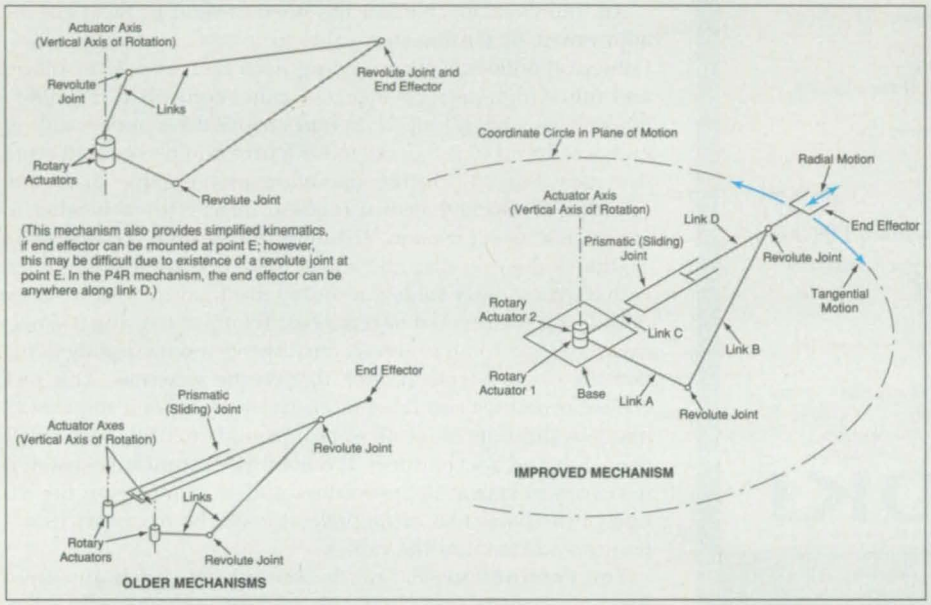
The figure schematically illustrates three manipulator mechanisms for positioning an end effector (a robot hand or other object) in a plane (which would ordinarily be horizontal). One of these is a newer, improved mechanism that includes two coaxial, base-mounted rotary actuators incorporated into a linkage that is classified as "P4R" in the discipline of kinematics of mechanisms because it includes one prismatic (P) joint and four revolute (R) joints. The improved mechanism combines the advantages of coaxial base mounting (as opposed to noncoaxial and/or nonbase mounting) of actuators, plus the advantages of closed-loop (as opposed to open-loop) linkages in such a way as to afford a simplification (in comparison with other linkages) of inverse kinematics. Simplification of the kinematics reduces the computational burden incurred in controlling the manipulator.

In the general case of a two-degree-of-freedom manipulator with two rotary actuators, the inverse kinematic problem is to find the rotary-actuator angles needed to place the end

effector at a specified location, velocity, and acceleration in the plane of motion. In the case of a typical older manipulator mechanism of this type, the solution of the inverse kinematic problem involves much computation because what one seeks is the coordinated positions, velocities, and accelerations of the two manipulators, and these coordinates are kinematically related to each other and to the required motion in a complex way.

In the improved mechanism, the task of coordination is greatly simplified by simplification of the inverse kinematics; the motion of the end effector is easily resolved into a component that is radial and a component that is tangential to a circle that runs through the end effector and is concentric with the rotary actuators.

If rotary actuator 2 is held stationary, while rotary actuator 1 is turned, then link D slides radially in the prismatic joint, causing the end effector to move radially. If both rotary actuators are turned together, then there is no radial motion; instead, the entire linkage simply rotates as a rigid body about the actuator axis, so that the end effector moves tangentially. Thus, the task of coordination is reduced to a simple decision to (a) rotate actuator 1 only to obtain radial motion, (b) rotate both actuators together to obtain tangential motion, or (c) rotate the actuators differentially according to a straightforward kinematic relationship to obtain a combination of radial and axial motion.



The **Improved Mechanism** affords a simplification of kinematics: Whereas the coordination of actuator motions necessary to obtain specified end-effector motions in the older mechanisms is a complex task, it is a relatively simple task in the improved mechanism.

This work was done by Farhad Tahmasebi of **Goddard Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Mechanics category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13655.

Improved Cable-Drive Pretensioner

Tension is adjusted easily by use of a worm gear.

Lyndon B. Johnson Space Center, Houston, Texas

An improved mechanism has been devised to facilitate the adjustment of tension in a cable in a cable-and-pulley drive. Cable-and-pulley drives are being used increasingly in robots and other high-performance, computer-controlled machines. Typically, a cable is looped around various drive pulleys with its ends anchored in proximity to each other on two coaxial cylinders (see figure). During operation of the cable drive, the cylinders are locked against rotation relative to each other to maintain a preset tension. To adjust the tension, it is necessary to unlock the cylinders and rotate them relative to each other.

In a typical older cable-tensioning mechanism, lock between cylinders is maintained by setscrews. To adjust tension, it is necessary to loosen the setscrews, turn the cylinders slightly to obtain the desired tension, then tighten the setscrews. This procedure is tedious and labor-intensive; sometimes it requires as many as three technicians working simultaneously with three wrenches and a screwdriver. If one of the technicians slips, it is necessary to repeat the procedure and, depending on the design of the particular cable drive, it could be necessary to dismount and remount the cables.

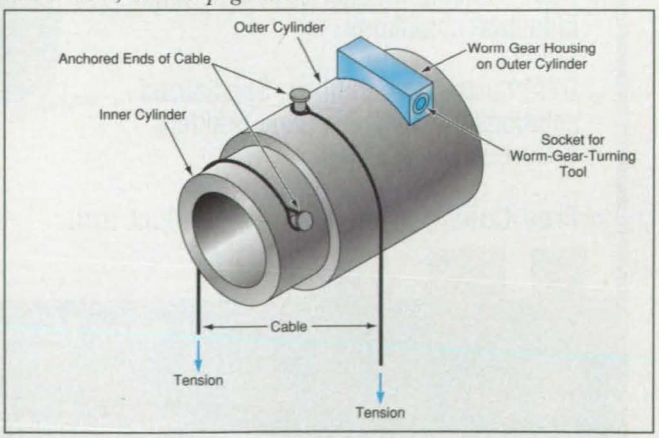
The improved mechanism is both a locking and an adjustment mechanism that can be adjusted easily by one technician. In this mechanism, the cylinders are turned relative to each other by use of a worm-gear drive. The outer cylinder houses the worm, while the mating worm gear is attached to the inner cylinder. A technician turns the worm by use of a hand tool. There is no need to provide explicitly for locking against inadvertent or undesired relative rotation: the friction inherent in the worm-gear drive prevents backdriving under cable tension.

This work was done by William Townsend of Barrett Technology, Inc., for **Johnson Space Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Barrett Technology, Inc.
545 Concord Avenue
Cambridge, MA 02138

Refer to MSC-22405, volume and number of this NASA Tech Briefs *issue, and the page number.*



Tension in the Cable Is Adjusted by turning one cylinder relative to the other. In the improved mechanism, this is done by use of a worm-gear drive.

Path-Planning Program for a Redundant Robotic Manipulator

This program utilizes kinematic redundancy to find singularity-free, obstacle-avoiding paths.

Lyndon B. Johnson Space Center, Houston, Texas

The Space Station Robot Manipulator System (SSRMS) Path Planning Program is a computer program that, in comparison with software developed previously for the same purpose, supports operations of faster and more complex robots. Two especially notable features of the program are that (1) it makes for ease of description of the work space of a remote manipulator or other robot and (2) it takes advantage of redundant degrees of freedom of the manipulator by finding manipulator-link paths that avoid both mathematical singularities and physical obstacles. The program can be applied not only to space-station manipulators and other robots but also to manipulators and other robots used in remediation of waste sites and dismantling nuclear facilities. With moderate modifications, the program could even be used in reconfigurable manufacturing operations.

In the original International Space Station application, there is a need to assure the safety of the crew and equipment by calculating a safe path and an optimal trajectory for the SSRMS, which has seven degrees of freedom (DOFs). In the absence of the present or a similar program, determining a safe path through a field of obstacles is difficult because the end-effector trajectory and the necessary manipulator-joint-angle trajectories must be taken into account manually; as a consequence, the chosen path may not be the optimal path. The SSRMS Path Planning Program automates the path-planning process. It searches for, and finds, the optimal trajectory in a matter of seconds.

The idea for the program came from R. V. Mayorga, who proposed a path-planning method for a manipulator that is redundant in the sense that the number of its DOFs exceeds the number of task elements. An analysis of the method was performed for a 3-DOF manipulator operating in a plane; then the analysis was extended to a 7-DOF manipulator

operating in three-dimensional space. Finally, all the equations of the method specific to the SSRMS were formulated, together with some clever ways of incorporating them into a computer code. The SSRMS Path Planning program, written in ANSI-C, evolved from this final analysis.

The SSRMS Path Planning Program follows the artificial-potential-field approach to planning the path of the end effector of the remote manipulator. Real-time joint-angle trajectory planning for enabling manipulator links to avoid obstacles, involving the use of a null-space vector, is implemented in this program. All of the equations of kinematics and inverse kinematics specific to the SSRMS are also included.

In Mayorga's method, the goal configuration is represented by an attractive potential and obstacles by repulsive potentials. The determination of the manipulator joint-angle trajectory involves the inversion of a potential-field matrix, but this is subject to difficulties when the manipulator approaches singular configurations. With respect to singular configurations, the SSRMS Path Planning Program incorporates two improvements: (1) the manipulator trajectory is determined directly from the gradient of the potential field, so that there is no need to invert nearly singular matrices; (2) a global perspective is added by providing for the predetermination of optimal (shortest-path) goal trajectory for the end-effector position. The attractive potential is then based on an optimal trajectory that guides the end effector around obstacles in the shortest possible distance.

The program reads two input files. The first file describes the work space; the second file contains constants, integration parameters, the initial configuration, and the goal configuration. From these inputs, the program calculates a path through the work space, going from the initial configuration to the goal configuration along a path that avoids obstacles for the end effector and the manipulator links. By varying the values of some or all of the constants, one can change a path to incorporate a wider or narrower clearance of obstacles, change the time to complete the task, and/or otherwise alter the nature of the task. The joint-angle trajectories are computed by another program, "PLUMECHECK," on a Silicon Graphics workstation. PLUMECHECK can display animation of the manipulator arm.

The SSRMS Path Planning Program is an improvement over programs developed previously for the same purpose in the following respects:

- Path planning has been automated. The joint-angle trajectories for any path can be found in seconds. Therefore, many different scenarios can be tried to find an optimal path.
- It is easy to describe the work space, including obstacles, forbidden regions, and other important features of the work space.
- The redundancy of the SSRMS is not a disadvantage for this program; on the contrary, it is an advantage when there is a need to find singularity-free paths and avoid obstacles.

The SSRMS Path Planning Program has much to recommend it. Its potential field-based approach to avoidance of collisions by kinematically redundant manipulators has already been demonstrated in research laboratories. This program is being evaluated with respect to commercial applicability.

This work was done by Glenn V. Webb of Rockwell Space Operations for **Johnson Space Center**.
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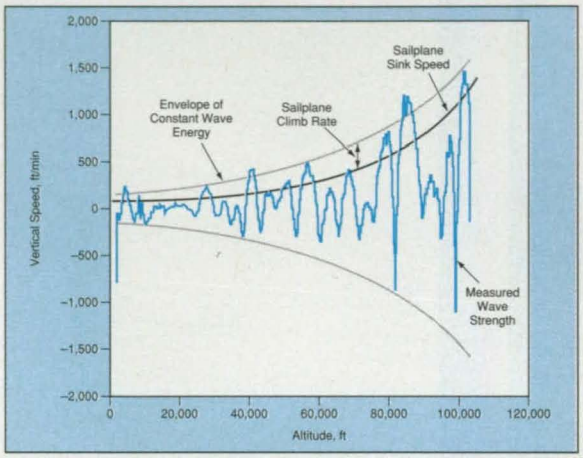
Soaring to 100,000 ft on Stratospheric Mountain Waves

A proposed sailplane would make the most of these waves.

Dryden Flight Research Center, Edwards, California

A research project now underway addresses the concept of utilizing stratospheric mountain waves to soar to high altitudes in sailplanes. Stratospheric mountain waves are mountain waves that propagate strongly, and with continuity, into the middle and upper stratosphere, and are not extinguished, trapped, or reflected at or near the tropopause. The historical experience of high-flying aircraft has been limited to the lower region of their domain, where large amplification leading to large vertical speeds and instability is uncommon. Amplification with increasing altitude, and the instability caused by this amplification, can lead to wave overturning, similar to waves breaking at the beach. Wave overturning originating from amplification has not been experienced by aircraft yet, as far as we know. The general impression of the stratosphere as an entirely quiet region is not, in general, justified.

Recently, high-altitude meteorological research balloons, launched in support of other atmospheric-science projects, have recorded very strong mountain waves (see figure) up to a balloon-burst altitude of 105,000 ft



Mountain-Wave Vertical Speeds are plotted alongside the sailplane sink rate and the corresponding estimated sailplane climb rate.

(32 km). The waves propagate into the middle or upper stratosphere when the outer region of the polar vortex lies above a strong tropospheric wind band, above mountainous terrain. In this situation, there is no appreciable wind maximum at the tropopause, and little evidence of a tropopause in the temperature profile. Waves propagate upward with increasing vertical wind component. Stratospheric mountain waves are most commonly found, in the Northern Hemisphere, in the 60°-to-70° latitude band. In the Southern Hemisphere, they extend further toward the equator, because of the larger extent of the polar vortex in that hemisphere. Stratospheric waves can also form (albeit very rarely) at lower latitudes.

The present project is the first step to build and demonstrate the utility of a special-purpose piloted research sailplane that can climb in strong stratospheric mountain waves to its lift-limited ceiling. For a sailplane with state-of-the-art structural and aerodynamic characteristics, the lift-limited ceiling lies between 100,000 and 110,000 ft (30.5 and 33.5 km). Flights are to be made safely and repeatedly, as justified by the need for experimental data.

Work to gather additional data on the strength, location, structure, and frequency of occurrence of strong mountain waves is now underway. The data are expected to verify that the aerodynamic performance of a sailplane will enable it to climb to 100,000 ft (30.5 km) in the waves. In addition, simulations are expected to determine what degree, if any, of stability augmentation will be necessary for the sailplane.

The meteorological part of the work will consist of identification and searching of historical sources of mountain-wave data. In addition to searching such pre-existing data, special dedicated balloon ascents with Global Positioning System (GPS) sondes will be made to augment the data normally obtained from sondes launched at regular intervals and from other special balloons that are used for research not related to stratospheric mountain waves. The meteorological profile characteristics will be summarized with respect to the characteristics of waves identified in the balloon data. Numerical modeling of mountain waves will be done for selected cases found in the data acquired from the sondes during the dedicated balloon ascents and from other sources.

The work will include an aerodynamic-performance part based on a standard "drag build up" method. This part of the work will involve the use of pre-existing basic data sources and of in-

cremental variations on pre-existing high-performance sailplanes for which accurate performance measurements have been made.

The simulation part of the work will include assessment of the flying qualities of the sailplane. With the Dryden simulation, actual or numerical models of the wave structure can be included. The direct effect of the wave structure on sailplane control can be shown. The effect of turbulence generated in wave overturning events will not be as realistically modeled. Variations of parameters will be made to determine the most attractive combination of aerodynamic stability and augmentation.

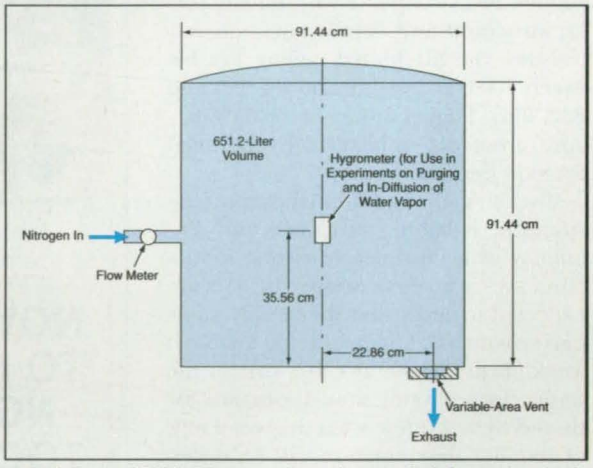
This work is being done by Edward H. Teets, Jr., of **Dryden Flight Research Center** *and by Einar Enevoldson of Norjen, Inc., under a Flight Test Technique grant and a Dryden Discretionary Fund grant. DRC-00-08*

Designing Purging Flows of Clean, Dry Gases

Flow parameters can be chosen to reduce contamination to specified low levels.

Goddard Space Flight Center, Greenbelt, Maryland

A method of designing purging flows of clean, dry gases to maintain acceptably low levels of contamination in enclosed volumes has been developed. The method is applicable to diverse enclosures that must be kept clean, including housings of precise optical instruments, clinical facilities, facilities for manufacturing microelectronic devices, and clean rooms in general.



A Tank Purged With Nitrogen through a single inlet and a single outlet was used in experiments to obtain parameters for purge-flow design equations.

In the simplest case, the purging flow of clean, dry gas is required to limit the entrance of external contaminants into the purged volume through a single purge vent (see figure). External contaminants include gases (e.g., water vapor) and particles (e.g., microbes and dust). Also, typically, the purging flow is required to limit the concentration of contaminants generated internally by outgassing and to sweep out these contaminants. The present design method, based on equations developed in a theoretical and experimental study of bulk and diffusional flow, enables one to select the pressure, flow speed, and volumetric flow rate of the purge gas to satisfy these requirements.

The purging volumetric flow rate needed to limit potentially contaminating external air to an acceptably low partial pressure is a function of its partial pressure, of the ambient pressure, and of the characteristic time for entry of air or of the contaminant(s) of interest into the volume through the purge vent. This characteristic time can be determined experimentally. The purge-gas pressure needed to maintain the required volumetric flow through the purge vent can be calculated as a function of the ambient temperature and pressure and the cross-sectional area of the purge vent. The speed of flow through the vent is, of course, directly related to the volumetric flow rate and the cross-sectional area of the vent. The size of the largest airborne particle that can be prevented from entering against the purging flow can be calculated as a function of the flow speed and of the viscosity and mass density of the vented gas.

This work was done by John J. Scialdone of **Goddard Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category. GSC-14241*

Books & Reports

Update on a Progressive-Failure-Analysis Software System

A report presents additional information on the GENOA-PFA computer program, which was described in "Software for Simulating Progressive Fracture in Braided PMCs" (LEW-16845), *NASA Tech Briefs*, Vol. 24, No. 3 (March 2000), page 52. On the basis of material-property data, finite-element mathematical models, and service conditions, GENOA-PFA simulates the initiation and progression of damage ultimately leading to global structural failures in composite-material structures. The composite materials include complex architectures in which fibers are placed in two- or three-dimensional weaves or braids. Whereas the cited prior article characterized GENOA-PFA as applicable to only polymer-matrix composites, the report characterizes it as applicable to other composite structures also, including ones that contain ceramic or metal matrices.

This work was done by Pappu L. N. Murthy and Christos C. Chamis of **Glenn Research Center**, *Frank Abdi of Alpha Star Corp., and Levon Minnetyan of Clarkson University. To obtain a copy of the report, "GENOA a Progressive Failure Analysis Software System," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16858.

Simulations of Evolving Transitional Mixing Layers

A report describes direct numerical simulations of single- and two-phase, temporally developing transitional mixing layers at Reynolds numbers (based on the initial vorticity thickness and mean velocity difference) from 200 to 600. As many as $300 \times 332 \times 180$ grid points were used to discretize the gas phase. As many as 5.7×10^6 individual evaporating droplets of various sizes, present in liquid-to-gas mass ratios between 0 and 0.5, were tracked in a Lagrangian reference frame. The gas phase was described by the Navier-Stokes equations for a compressible fluid, augmented by species-transport equations and by the energy equation.

This work was done by Josette Bellan and Richard Miller of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Evolution of Single-Phase and Droplet Laden Transitional Mixing Layers," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20705

Simulations of a Transitional Droplet-Laden Mixing Layer

A report describes direct numerical simulations of a droplet-laden mixing layer (e.g., evaporating droplets of a hydrocarbon fuel in air) undergoing a transition to mixing turbulence. The governing equations are those of Lagrangian transport of discrete droplets through a flowing gas, which is represented by Eulerian equations with source terms for two-way couplings of mass, momentum, and energy among the liquid, vapor, and carrier-gas phases. The equations are solved numerically, using as many as 18×10^6 grid points to discretize the Eulerian gas-phase equations and tracking as many as 5.7×10^6 evaporating droplets of various initial sizes in the Lagrangian reference frame.

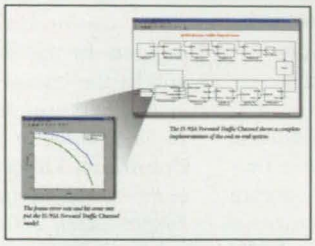
This work was done by Josette Bellan and Richard Miller of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Direct numerical simulation and subgrid analysis of a transitional droplet laden mixing layer," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20709

Thermodynamic Instability of $In_xGa_{1-x}As/GaAs$ Quantum Dots

A report describes experiments that generated evidence of thermodynamic instability of nanometer-size islands (quantum dots) in $In_xGa_{1-x}As$ grown on GaAs. $In_xGa_{1-x}As/GaAs$ specimens were grown by metal-organic chemical vapor deposition, using various partial pressures of AsH_3. Examination of specimens by force microscopy, electron microscopy, and low-temperature photoluminescence spectroscopy revealed differences in island formation at different partial pressures of AsH_3, including differences in (1) surface coverages of islands, (2) ratios between numbers of coherent and incoherent islands, (3) sizes and shapes of islands after annealing, and (4) thicknesses for the onset of the Stranski-Krastanow (S-K) transformation (in which quantum dots form spontaneously in a second semiconductor deposited on a lattice-mismatched first semiconductor once the second semiconductor reaches a critical thickness, which is typically a few molecular layers).

This work was done by Rosa Leon of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Island Shape Instabilities and Surfactant-Like Effects in the Growth of InGaAs/GaAs Quantum Dots," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20696

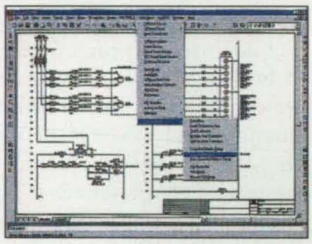
New on DISK



CDMA Software for Wireless

CDMA Reference Blockset 1.0 from The MathWorks, Natick, MA, is a collection of Simulink® blocks for creating and simulating the CDMA IS-95A standard for wireless communications. It enables users to construct an entire, end-to-end (transmitter to receiver) reference model of a wireless system. The software includes full C source code, providing an open and upwardly compatible foundation for migration of IS-95A designs into CDMA 2000 1x and other third-generation CDMA applications. Building blocks are included for the design of base stations, handsets, and components. Other features include drag-and-drop editing, intuitive model navigation, model-library support, and lockable libraries. **Circle No. 710**

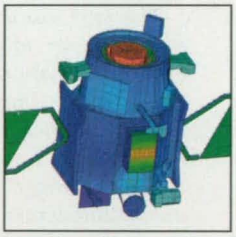
Electrical-Controls Design



VIA Development Corp., Marion, IN, has released Version 6.0 of its VIA Electrical Controls Design Software (VIA ECDS). This AutoCAD®-based application suite is designed to link schematics, panel drawings, bill of materials, and database management. Enhancements include the Locator, which allows users to search multiple drawings for any specific attribute value, and a Setup Wizard to facilitate project configurations. VIA Module Builder enables users to create new I/O modules or modify the appearance of existing modules. **Circle No. 711**

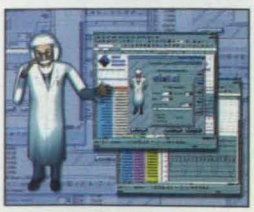
Thermal Modeling Plug-In

Network Analysis, Tempe, AZ, offers two products integrating its SINDA/G thermal software with FEMAP, SDRC's Windows-based FE modeler. SINDA/G for FEMAP is a plug-in module for FEMAP and MSC/NASTRAN for Windows. It consists of a SINDA/G thermal-solver module combined with integration software to transfer FE models to finite difference models solved with SINDA/G. SINDA/ATM (Advanced Thermal Modeler) is a bundled thermal-analysis solution consisting of SDRC's FEMAP Professional and NAI's SINDA/G thermal analyzer. A menu-driven interface allows engineers to create, solve, and visualize complex thermal simulations with forced and natural convection and radiation. **Circle No. 712**



Data Acquisition Link

DoctorDAQ™ from United Electronic Industries, Watertown, MA, provides a link between the company's PCI-based data acquisition cards and the Microsoft Excel® spreadsheet program. This utility, available in a one-channel analog-input Lite version, imports individual samples or large waveforms directly into an Excel worksheet. The add-on also can use worksheet data as a source for output functions. Features include a continuous mode that obtains and displays the next set of datapoints from the analog-input buffer; it does this continuously until the user stops the process manually. **Circle No. 713**



New on the MARKET

Stereoscopic Visualization

StereoGraphics Corp., San Rafael, CA, offers the Monitor ZScreen® 2000 and Monitor ZScreen® 2000i. These stereoscopic visualization systems are designed for professionals who work with complex 3D images in GIS/mapping, molecular modeling, medical imaging, and computational chemistry. Each system consists of a stereoscopic viewing panel, which mounts over the monitor screen, and passive, polarized eyewear. Monitor ZScreens shutter images at the screen level, enabling users to view complex images stereoscopically on a workstation. These products are well suited for dual-monitor displays where synchronizing the vertical refresh rates of both monitors may not be possible. **Circle No. 721**

Servomotors and Gears

PSA rotary actuators from EXLAR Corp., Chanhassen, MN, combine a brushless servomotor with planetary gears to provide a fully integrated servo-gear motor. The sun gear is an integral part of the motor rotor, eliminating all couplings. PSA rotary actuators are available in frame sizes of 60, 90, and 115 mm. They provide continuous torque ratings from 15 to 750 lbf-in with single reduction ratios of 3:1, 5:1, and 10:1. Base motor speeds of 2400, 3000, and 5000 rpm offer a wide range of application solutions. **Circle No. 722**

DC Power Supplies

The PAC/PAC-R series of regulated CV/CC power supplies from Davis Instruments, Baltimore, MD, is designed to provide a compact power-supply package. Twelve types are available for power requirements ranging from 0 to 20-60 volts and 0 to 1-3 Amps. Features include remote-control terminals, low ripple and noise characteristics, simultaneous display, floating output and remote-sensing terminals, and series/parallel operation. **Circle No. 724**

Image-Storage System

Olympus America, Industrial Products Group, Melville, NY, has introduced the DC-10 QwikStore™ portable image-storage system, which attaches to rigid or flexible borescopes. It allows inspectors to view, freeze, store, export, and e-mail images. Operators view images on an integrated screen designed with a sun visor to eliminate glare. The system includes a FlashPath card and adapter that enable users to transfer images from the system to a laptop for e-mail. Applications include *in situ* inspections of turbine blades, compressors, hydraulic cylinders, critical welds, and other areas. **Circle No. 725**

Digital Projector

Boxlight, Poulsbo, WA, offers the XD-9m digital projector that weighs 4.8 pounds and beams 1000 ANSI lumens. The laptop-sized unit features Digital Light Processing technology and true 1024 x 768 XGA resolution. Other features include electronics that identify a computer's video signal and set up the picture automatically; and an on-board DVI connector for digital/analog connectivity. Also included are digital keystone correction, manual zoom/focus, and a remote control. **Circle No. 720**

New LITERATURE

Pneumatic and Fluid Control Valves

The Specialty Mfg. Co., St. Paul, MN, has released a 24-page, full-line catalog of pneumatic and fluid control valves. It provides detailed specifications and ordering information on miniature two-, three-, and four-way valves; needle valves/pinch valves; shuttle valves/check valves; pressure regulators; controllers; and fittings. Products are offered in 10/32" and 1/8" NPT, female, male, and barb end connections. **Circle No. 700**

Switches and Controls

A brochure from American Solenoid, Somerset, NJ, outlines the Kraus & Naimer line of electrical controls. Rotary cam switches are available with different contact designs, materials, and terminals. Applications include process control, instrumentation, and motor control. Other products include pushbuttons, relays, contractors, motor starters, and optional extras. **Circle No. 701**

RFI Products

VXI Associates, Boonton, NJ, offers a brochure describing its services and solutions for Receiver/Fixture Interface (RFI) requirements. RFI is an open-system architecture offering fixture upward transportability and low-cost kit wiring support. Through standard RFI Fixture Eurocard packaging and protoboard design, the company provides common buffering, switching, and termination circuit-board types that can be applied directly through standard fixture power and control line hook-ups. Products include the Model 180 RFI System Series, designed for a broad range of commercial/aerospace requirements. **Circle No. 702**

Encoders and Sensors

The 2000 product catalog from Piher International Corp., Libertyville, IL, offers a full line of carbon and cermet trimmer and control potentiometers, incremental encoders, position sensors, and printed resistors. The 92-page catalog includes product specifications, dimensions, schematic drawings, and a worldwide distributor network. **Circle No. 703**

Digital Pressure Test Gages

DCT Instruments/Sensotec, Columbus, OH, offers a brochure featuring specifications and ordering information on the Model AK (0.05% FS accuracy) and the J Series (0.2% FS accuracy) gages. These stainless-steel digital pressure test gages use sensor technology designed for overpressure tolerance. The J Series and the Model AK are offered with gage, absolute, vacuum, or compound pressure reference, in ranges from .5 to 60,000 psi. **Circle No. 704**

Industrial Computers

Siliconrax, Sunnyvale, CA, offers an 80-page catalog describing its line of industrial computer systems and accessories. In addition to complete systems, products include single-board computers, passive backplanes, rack-mount enclosures, NEMA 4/12 workstations, tower enclosures, rack-mount monitors, rack cabinets, keyboard enclosures, and UPS and power supplies. **Circle No. 705**

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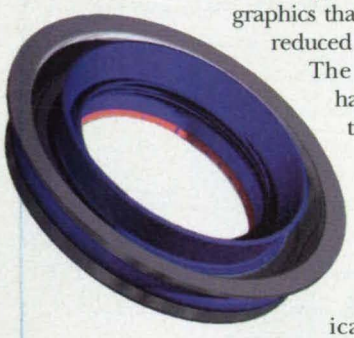
This Month in

Rapid Product Development online

The web publication for *NASA Tech Briefs* readers

*NASA Tech Briefs' all-digital publication, Rapid Product Development Online (**www.rapidproducts.net**), helps engineers develop better products faster by providing immediate 24-hour access to the latest information on CAD, FEA, modeling, mold-making, reverse engineering, and rapid prototyping tools and techniques. This month's RPD Online includes:*

New CAD Process Reduces Mold-Design Time to 10 Minutes



Freudenberg-NOK, a provider of sealing packages for both automotive and non-automotive applications, adopted a new design process with Unigraphics that essentially parameterized an entire mold and reduced design time from 30 to 60 hours to 10 minutes. The new technology from Unigraphics Solutions has made it possible to reduce prototype delivery time from four to eight weeks to 10 working days.

In essence, a solid model of the product is used to update a solid model of a generic mold, automating the most time-consuming part of the product development process. The toolpath information, associated to the generic mold, is automatically updated and ready for CNC machining.

www.rapidproducts.net/JULY00/mold.html

Internet-Enabled Rapid Prototyping

Rapid prototyping has drawn life from the Internet through rapid information and data exchange. Now that the "dot coms" have entered the rapid prototyping marketplace, what will the future hold?

As this month's guest columnist, Todd Grimm — director of marketing for Accelerated Technologies, Inc., a rapid prototyping service bureau — discusses possible answers to this question. "Only one fact is known," says Grimm. "If these Internet solutions don't make it easier, faster, better, and cheaper for both sides of the supply chain, they will fail."

www.rapidproducts.net/JULY00/tgrimm.html

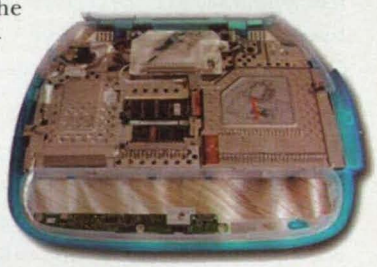
New Product Highlights

This month's new products include VX Vision® Mold Edition™ from Varimetrix Corp., Palm Bay, FL. Mold Edition is a specially configured version of the company's VX Vision CAD/CAM system. It is optimized for the design and documentation of injection and blow molds for plastic parts.

www.rapidproducts.net/JULY00/products.html

3D CAD Helps Integrate Components in New Laptop Design

While integrating components in a laptop is always difficult, the Apple Computer Corporation's iBook presented an exceptional challenge because its curved shell both reduced the available space and increased the complexity of interference calculations.



The iBook integration team overcame this challenge by switching from the 2D drawing software usually used for this task to a new Macintosh-based 3D CAD system from Diehl Graphsoft. The CAD tool provided a quick and easy way to evaluate how components fit in various positions, to establish basic design relationships, and to homogenize communications between electrical and mechanical engineers and industrial designers.

www.rapidproducts.net/JULY00/laptop.html

Be sure to visit www.rapidproducts.net for the latest information on the rapid product development industry.

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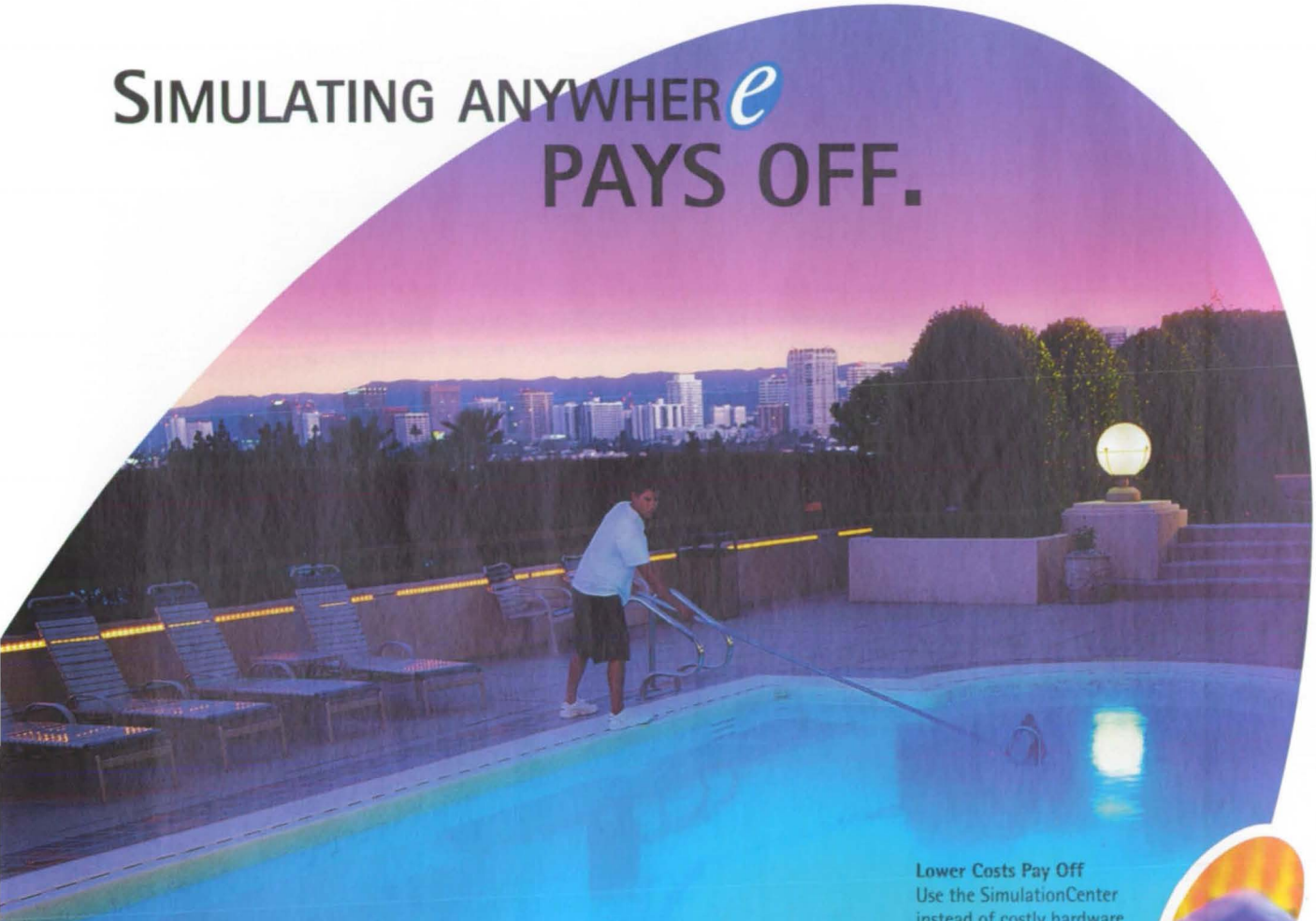
SIMULATING ANYWHERE *e* PAYS OFF.



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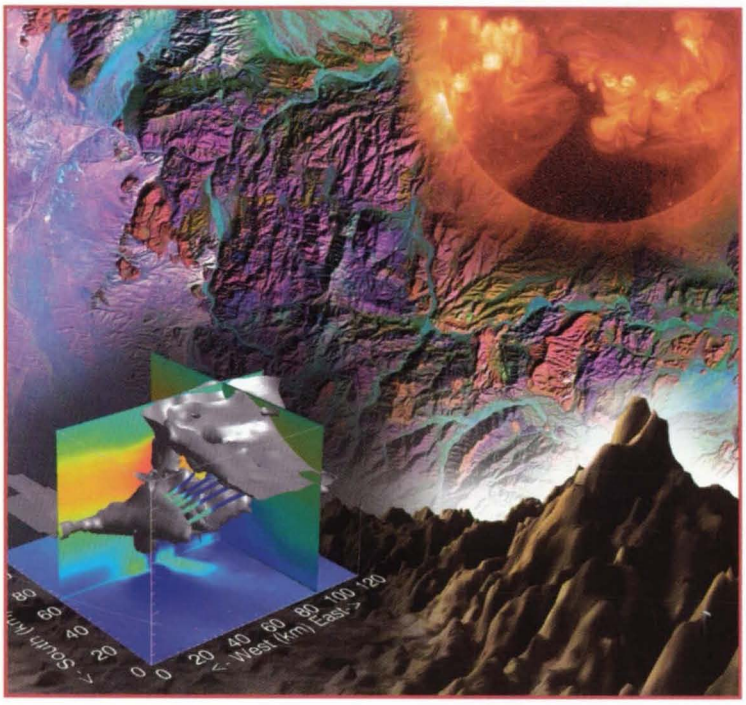
The Power of IDL



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For More Information Circle No. 508

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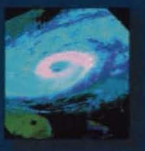

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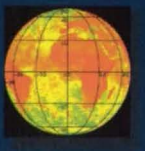

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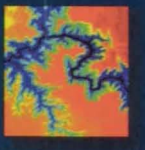

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